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ENGINEERING MAGAZINE

DEVOTED TO

INDUSTRIAL PROGRESS

ENGINEERING SOCIETY
SCHOOL
OF
PRACTICAL SCIENCE,
TORONTO.

VOLUME VII

April to September, 1894

NEW YORK

THE ENGINEERING MAGAZINE CO.

1894

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THE

ENGINEERING MAGAZINE

VOL. VII. APRIL, 1894. No. 1.

THE OUTLOOK FOR AN IMPROVEMENT IN BUSINESS.

By J. Edward Simmons,

President of the Fourth National Bank of New York.

AFTER a period of severe sickness it is generally expected that a patient will recover slowly. There is a stage in every disease which is called the turning-point, and I believe that, after the long siege of depression and general financial and commercial demoralization we have had in the United States, the turning-point has finally been reached. The reason why I believe this, is that, so far as I can judge, liquidation has ceased to a very great extent. The pressure of the panic forced men to liquidate, and the alarm created by that pressure has caused them to continue liquidation until they are now practically out of debt. There has rarely been a time when the outstanding obligations of merchants were so small as at present. This is exemplified by the large accumulation of money at the great money-centers and the scarcity of commercial paper for either sale or discount. The rate at which good borrowers can get money is unprecedentedly low, and the banks are overflowing with resources that they cannot invest.

The business of the whole country has been greatly curtailed by pending legislation at Washington, and until this legislation is completed we can hardly expect a *general* improvement in financial and commercial circles. The inflation of the currency, by the purchase of silver bullion for treasury notes convertible into gold, was, in my opinion, the principal cause of the panic. Since this process has been in existence the accumulation of silver bullion by the government has been enormous, and at present prices the loss to the government would be, through the sale of all the silver it has purchased under the Sherman act, more than $100,000,000. And yet, with this immense loss staring us in the face, many of our legislators at Washington favor the

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continuance of inflation by urging the coinage of the seigniorage, which will not add a farthing to the price of silver or a dollar of value to any mining interest. Every one who has given the subject a moment's thought must know that each new dollar put into circulation makes more difficult the convertibility of the nearly $600,000,000 of silver the gold-reserve is already called upon to carry. The stoppage of silver purchases by the repeal of the Sherman act has given relief to the financiers of the whole country, and we now find that we are, for the first time in many years, upon a solid and substantial financial basis. Therefore, we must say that, as far as financial legislation is concerned, our condition has improved. Let us hope that no backward step will be taken.

Ever since the introduction of the Wilson bill all sorts of gloomy forebodings have been entertained by those who were to be directly or indirectly affected by the changes proposed therein. The Wilson bill, by an unprejudiced mind, can hardly be regarded as extreme, and now that the people are familiar with its prominent features less alarm is apparent. The passage of the bill is believed to be near at hand, and with the settlement of the tariff question the merchants will soon adjust themselves to the new conditions and business must necessarily drift back to its normal state.

This is beginning to be anticipated by some of our leading financiers, as reflected by the improvement in the prices of securities. The Stock Exchange is a good barometer of public opinion. Disaster is generally indicated by the fall of prices, and prosperity by an advance in Stock Exchange quotations. The market of late has moved up a little all along the line. This has been caused, not by any settlement of receiverships, but by the confidence which is returning to investors in the ultimate restoration of values and the resumption of business prosperity.

Six great trunk-line railroads are in the hands of receivers, beside many smaller railroads, representing nearly $2,000,000,000 of securities, upon most of which interest has been suspended temporarily. But the reorganization committees are all working under the favorable conditions of easy money, and it is fair to anticipate an early return of railroad properties to the owners. In the meantime, the public should bear in mind that these railroads are all in operation and are likely to continue to be until their obligations are adjusted and the receivers discharged. I confidently believe that no other great railroad lines are now in danger of embarrassment.

It is true that the railroads which have not been embarrassed show a heavy average decrease in gross earnings, but there has been a corresponding heavy decrease in operating expenses, as a result of which, in some instances, the current reports show an actual increase in net earnings. This would indicate a comparatively healthful state of the financial condition of the railroads. Another favorable feature of the situation grows out of the economy which the railroads have been practising. Since the date of the Baring failure, in 1890, the railroads have been reducing expenditures—a fact well known to those in the business of selling supplies to the railroads—and since the panic of last summer they have been forced to the very limits of the most rigid economy. It follows of necessity, therefore, that they must soon be in the market again for supplies; and such of them as are sufficiently strong financially are already reënforcing their equipment because of the exceptionally low prices now prevailing. Steel rails, for instance, are sold lower than ever before.

What is true of the railroads is true, to a greater or lesser degree, of the people. The demoralization caused by the panic has resulted in a spirit of economy that seems to have taken possession of every one. The rich man, although abundantly able to satisfy his desires, is reluctant to spend money, unless absolutely necessary, because of the prevailing distress. When 65,000,000 people retrench, the benefits that accrue from frugality must sooner or later be felt. Upon every hand there has been a great curtailment of production, but consumption and wear and tear have been going on all the time; and it is fair to presume that stocks of goods are rapidly decreasing and that it will not be long before the demand in all directions will be greater than the supply.

There was no fall trade last year, and the delay in legislation at Washington has killed the spring trade. The people are now anxiously looking forward to the crop period; and if the harvest is up to the average and we have a good foreign demand, as it is fair to think that we will have under existing low prices, the entire purchasing power of all our crops for this year will come against a greatly diminished supply in each and every branch of manufacture. With a people so easily stimulated, so ambitious, and so enterprising as Americans are proverbially known to be the world over, it must be apparent to any thoughtful mind that the stimulation which the marketing of the crops will produce throughout all lines of industry and commerce must restore confidence with a swing; and as a result we may reasonably look for a speedier revival next fall than a long period of depression under other circumstances would permit us to hope for.

We are having no trouble from a lack of money. We have to-day a larger circulation per capita than any other nation in the world, except France. We have about $25 per capita, while France has somewhere in the neighborhood of $45; but our advantage over the French people is that while they have but few banks, we have banks everywhere, and the great bulk of our business is done by checks and drafts rather than by actual payments of cash money. Ninety per cent. of all the business of this country is done by checks and drafts, which are the real currency of commerce. The fact that our existing currency is amply sufficient for every possible demand in the near future is shown in the enormous accumulations of idle money in every money-center throughout the United States. There is as much money in the country as there ever was. The only loss that we have sustained in money has been represented by the outflow of gold to Europe. That has been more than offset by the outflow of silver certificates and treasury notes from our treasury department, together with the issue of national-bank notes, so that, as far as our currency is concerned, we are still upon an inflated basis, but we have, I hope, wisely stopped inflating.

In this connection there must be taken into account the immense increase of wealth in this country. All the statistical proof is to the effect that the accumulated wealth of the civilized world has actually doubled in the past generation, and the wealth of the United States has shown more than a proportionate increase. People who look back at the panic of 1873 and say that it will take years to recover, overlook the fact that we have an enormous surplus of wealth that did not exist in 1873, and that the owners of this accumulated wealth are ready and eager to embark it in profitable enterprises.

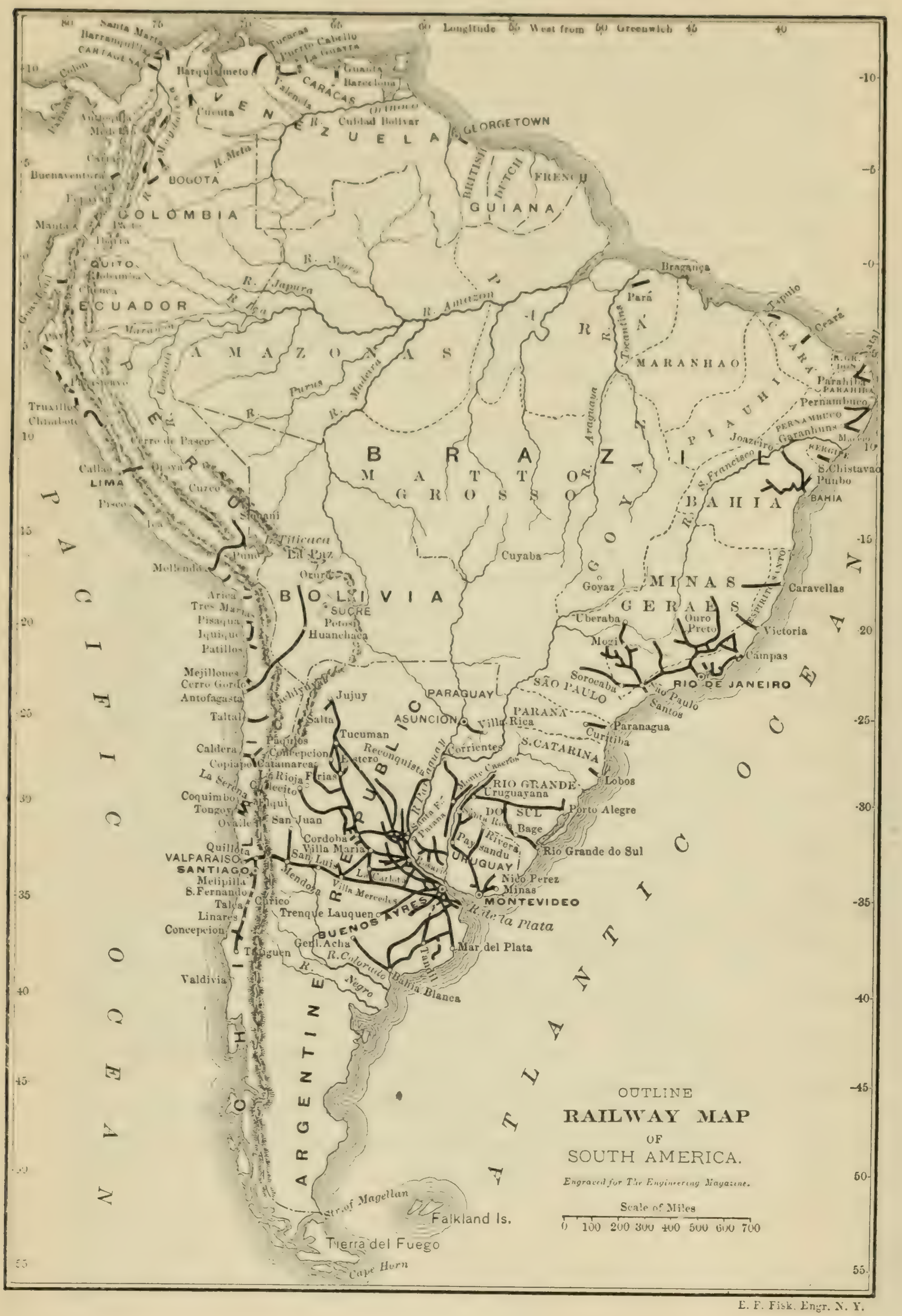
The United States offers the most tempting field for investment of any country in the world. The rate of interest paid here is larger, and the security offered is better. European money seeking investment, including the proceeds of securities that have been sent to this country and sold because of the fear of foreign capitalists that we were going to a silver basis, and that unless they obtained gold while gold was obtainable they would be obliged to sell their securities and take payment in a depreciated currency—a large part of that money will certainly seek reinvestment here because the United States has firmly placed itself upon a gold-paying basis.

This investment demand from abroad, together with the large accumulation in this country of cash seeking investment, will ultimately cause a reëstablishment of values, and will foster enterprise and stimulate trade. Indeed, we may confidently look for a return of that period when English capital will have representatives in this country for the special purpose of making investments, exactly as was the case for the few years preceding the panic.

There is a point in the situation that is especially encouraging, namely, that with all the decline that has taken place in securities, in manufactured goods, and in everything else produced, there has been little decline in the price of labor. Labor, with few exceptions, commands as high a price as it ever commanded ; and, in spite of the vast number of people said to be unemployed, the employed are willing to strike in case wages are reduced. This shows that the workers are not as poor as some of the newspapers have represented them. It also shows that they are still receiving good wages and are still buying in the market,—that greatest of all markets, our home market. In other words, to my mind, as I have studied this question; one of the most striking evidences of declining prosperity is the tendency of wages to decline and thus reduce the purchasing power of the wage-earner, just as the decline in the price of wheat reduces the purchasing power of the farmer.

Again, with all the falling-off of business, there has not been a corresponding falling-off in expenses as far as rents are concerned. There has been very little concession upon the part of the lessor to the lessee. Real estate in New York has held up remarkably well, except in unfavored quarters of the city. The decline in real estate that has been predicted is not likely to come at all, with the reëstablishment of confidence and the renewal of business activity. Real estate is the last thing to go down. When a man feels that he cannot continue in his store unless he gets a reduction of rent, then the landlord may make a concession of rent. But the value of improved property is estimated upon what it yields ; and if lower rentals are obtained, of course the valuation placed upon the property must be less. The tenacity with which real estate has maintained its value may be accounted for in part by the general disturbance of confidence in corporate securities and the disposition of investors to put their money in real estate, where they can see it and control it without the aid of a board of directors. Altogether, the fact that no great decline in real-estate values has yet occurred, shows that the ravages of the panic have not been as far-reaching as many gloomily-disposed persons have thought. Furthermore, it shows that our people, because of the long period of prosperity in business circles which preceded the panic, were better fortified than ever before to meet the great decline that has taken place in mercantile and in security values.

Improvement appears on every side. The clouds have lifted. The skies have cleared, and there is warrant for confidence. The business turning-point has finally been reached.



OUTLINE

RAILWAY MAP

OF

SOUTH AMERICA.

Engraved for The Engineering Magazine.

Scale of Miles

0 100 200 300 400 500 600 700

E. F. Fisk, Engr. N. Y.

SOUTH AMERICAN RAILROAD DEVELOPMENT.

By Courtenay DeKalb.

THE development of railroad communication in South America has taken place under conditions so dissimilar to those obtaining elsewhere in the world that the results have been widely different, both to the countries concerned and to the railroad corporations themselves. The first incentive to that continental expansion of railroad systems which we have witnessed in the United States was the wealth to be derived from colonizing immense grants of virgin land. Our roads grew as a necessary adjunct to a gigantic pioneering movement. They have changed unpeopled deserts into great and flourishing states, and they stand to-day in such a legal relation to the commonwealth as insures a steady improvement of their facilities for handling a growing commerce. In South America numerous political subdivisions have restricted the growth of highways within comparatively narrow territorial limits, and opposed that free expansion to which the physical peculiarities of the continent might otherwise have led. Thus we find isolated groups of roads, national systems instead of great trunk-lines, and in general a lack of diversity in the products of the territory served by each system. This results in a scanty interchange of domestic commodities and causes great inequalities in the movement of freight at various seasons of the year. Moreover, the South American railroads have not furthered colonization on a scale comparable in any degree to what has taken place in North America, and such a result has not been relied upon to produce any immediate augmentation of traffic. An existing commerce of some magnitude or mines certain to yield a fair amount of freight have constituted the controlling motives in most instances.

In many cases, however, there has been no reason in the nature of things for the construction of railroads in South America—no important commerce seeking an outlet, no mines to be developed, nothing, in short, but a local ambition to emulate the progress of more favored regions; but the prospect of returns from a government guarantee of interest has induced capital to enter almost as readily into such unworthy enterprises as into those where profits could be foreseen from actual traffic receipts. Financial and political difficulties have very naturally followed, and indeed the system of government guarantees has throughout proved a source of discord and trouble, and has reacted upon the management of the railroads in such wise as to lessen their usefulness. The evil was, however, in a measure forced upon South America. Various circumstances combined to render the Latin continent unattractive to emigrants and to capitalists, so that it became necessary to hold out special inducements for the building of railroads. This might have led to no ill results if the proper functions of such highways in the promotion of national growth had been understood, but the concentration of the bulk of population near the seacoast, in a sort of fringe around the continent, caused these countries to take a narrow view of the situation. Attempting to develop the resources of a large number of these coast communities, they sanctioned the construction of numerous short lines running a few miles into the interior from separate ports, so that interstate commerce was not promoted, and, instead of leading to industrial progress, they merely increased the quantities of the same class of products which had been shipped before.

This is particularly true of Brazil, where, out of eighty-four separate lines, representing a total of about 6000 miles, not more than twelve lines, comprising about 1700 miles of track, are earning their operating expenses. On the majority of the Brazilian roads the expenses are fully a fourth more than the gross receipts. The government has guaranteed interest on a capitalization of $135,000,000 and has already paid in such guarantees more than $80,000,000, while the maintenance of this expensive luxury drains from her vaults every year no less than $9,000,000. Thus there has been a total outlay of foreign capital and interest paid by the state on unproductive roads reaching the enormous sum of $215,000,000,—enough to have constructed a great system of roads connecting every state on her Atlantic coast, even allowing so liberal a cost as $50,000 a mile. The cost of the guaranteed roads has frequently exceeded this amount, but it is noticeable that the unguaranteed private lines have frequently cost no more than $35,000 a mile. That such a great Brazilian trunk-line would share a better fate than the present isolated roads is a warrantable deduction from the fact that in the state of São Paulo, south of Rio de Janeiro, where a group of railroads aggregating 1200 miles in length is connected into a system ramifying far into the interior, every line is paying expenses, and some of them, after meeting all fixed charges, are paying dividends of 14 per cent. on their common stock. Furthermore, the Central (or Dom Pedro Segundo) railroad, which connects the São Paulo system with Rio de Janeiro, is earning a net profit of more than $2,000,000 per year on its 460 miles of track. It is through this region of Brazil that we find the greatest diversity of occupations; it is here that we find mechanics and manufacturers as well as agriculturists and traders. Within the last few years the railroads of Rio Grande do Sul have also grown into an extensive system, reaching across to Uruguay in the southwest, and the same phenomenon of prosperity is being repeated here; factories for making cotton and woolen goods, candles, soap, combs, buttons, and articles of leather have been established, a larger acreage has been brought under cultivation, and the railroads are at last beginning to earn their guarantees.

It is fortunate for Argentine that she inherited from the colonial era widely-separated centers of population. In the east were the Platine settlements of Buenos Ayres and Santa Fé. Far in the west, beyond the pampas, lay Mendoza; huddling in the foothills of the Andes in the northwest were Tucuman and Catamarca; while midway, where the Sierra de Cordoba breaks the broad expanse of plain, had grown the colonies of Cordoba and San Luis. The products of these various districts also differ greatly. In the north prevailed a semi-tropic climate, while farther south conditions favored cattle-raising and the culture of wheat and other cereals. Thus it happened that the Argentine railroads extended over large areas, and threw off branches at many points, serving a widely-diffused population. Trunk-lines and systems of roads became the rule, and rapid development took place in all directions. The first section of the Buenos Ayres Great Southern railway was opened in 1864. Others soon followed, and by 1880 there were 2473 miles in operation. The stimulus of improved transportation facilities now became felt more strongly, and line after line was built, until, by the end of 1893, the Argentine railroad board reported a total service of 8111 miles, representing an invested capital of $390,000,000, yielding a gross annual revenue of $24,000,000. The average of invested capital per mile is accordingly $48,082, with gross returns averaging $2958 per mile. It is interesting to compare these figures with similar statistics of railroads in the United States, where a total of 170,601 miles of track represents an absorption of $11,110,335,276, or $65,124 per mile, yielding a gross revenue of $1,138,024,459, or $6670 per mile.* The gross receipts in the United States amount to 10 per cent. on the invested capital, whereas in Argentine the receipts are 6 per cent. on the capital. It is not easy to make a fair comparison of operating expenses in the two countries, owing to the absence of complete data, but on nine representative Argentine roads, aggregating 4330 miles of track, the expenses in 1892 consumed 71 per cent. of the gross receipts, while the average on all railroads in the United States for 1891 amounted to 68.83 per cent.

The influence of this great system of roads has been to transform Argentine in thirty years from a pastoral country, producing only hides and tallow and wool for export, into an agricultural and manufacturing country ranking among the great producers of the world. To be more specific, her sheep-ranches yield a gross annual product of $77,000,000, her cattle-ranches $39,000,000, her farms $86,000,000, her vineyards $8,000,000, and her miscellaneous industries, including manufactures, $183,000,000. The transition from cattle- and sheep-raising to farming and general industries still goes on apace, as may be illustrated by the increase in tonnage carried by the Buenos Ayres Western railway, from 315,000 tons in 1892 to 493,000 tons in 1893, the gain being due entirely to the substitution of wheat-farming for sheep-breeding. The Argentine railroads, with the exception of that small mileage lying east of the Rio Paraguay, constitute a continuous system radiating from Buenos Ayres throughout the populous portion of the republic, connecting with Bahia Blanca, 445 miles to the southward, with Jujuy, close to the Bolivian frontier, nearly 1000 miles in the northwest, and with Mendoza, at the base of the Andes, 649 miles to the westward.

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* These figures are from Poor's Railroad Manual for 1892.

In Chile new conditions are found. The country is narrow, varying from 40 to 200 miles in width, and is intersected by numerous valleys, so that the natural tendency has been to bring the products of the Chilean mines and farms by the shortest routes to the sea. Yet, in spite of circumstances which clearly indicated numerous port-feeding railroads as a first necessity, the Chileans, with commendable wisdom, have encouraged the construction of a north-and-south trunk-line which parallels the Pacific coast for a distance of 350 miles. This has materially promoted her rapid growth as an agricultural and manufacturing country. Technical industries have reached a higher development in Chile than in any other portion of South America, and the urban population has increased to about 80 per cent. of the total enumeration for the republic. The government is now striving to arrest this tendency to concentration of the people in cities, and to this end is proposing changes in the railroad law which are expected to bring into existence a large number of branch lines radiating through the rural districts, which, by cheapening freights, will improve the condition of the farmers. Out of a total of 1846 miles of railroad in Chile, the government owns and operates 686 miles. Complete returns from the private lines are not available, but full statistics concerning the state roads show that they represented, up to December 31, 1891, a gross expenditure of $58,752,787, or $85,674 per mile. The receipts for 1891 were $10,151,196, of which the expenses consumed 82 per cent., leaving a net revenue of only $1,827,216, or $2687 per mile.

The Chileans confess that state management of railroads has not proved economical, and a project is on foot for leasing all the government roads to private corporations. As a rule the railroads of this republic have been costly, and the traffic fluctuating, so that the returns have never been continuously satisfactory. It is thought that a better balance of commerce will be established by a continuation of the present central system southward into Valdivia, where an immense timber and agricultural region awaits development. The effect of the transandine road when completed will also be important, as Chile will then be brought into reciprocal relations with Argentine. There remain only forty-three miles to be built to afford through communication between Valparaiso and Buenos Ayres. Twenty-two miles, of which nine miles will consist of tunnels, are on the Chilean side. Of the remaining twenty-one miles, on the Argentine side, 2⅝ will be tunnel work. The Chilean government will increase its guarantee of interest to 5 per cent. on an estimated cost of $7,000,000 necessary to complete the western section of the line, and the Argentine section will progress *pari passu* until the rails meet on the summit level. Tickets are now sold at $60 between Buenos Ayres and Valparaiso. and at $200 between London and Valparaiso via this route, the gap between Punta de las Vacas in Argentine and Salto del Soldado in Chile being traversed on mules, although a stage-coach service is promised by June, 1894. The distance between the Argentine capital and the great Chilean port is 882 miles, and the present intention is to charge at the rate of $87.27 per ton for freight between the two points. This of course will preclude the shipment of through freight, but there is a large commerce crossing the Andes between the two republics, and such a rate of 9.89 cents per ton per mile will be a great boon, and will certainly stimulate an exchange of products.

Three railways are in operation already across the lofty western cordillera of the Andes. The first in point of time was the Southern Railway of Peru, connecting the port of Mollendo with Puno, on Lake Titicaca, at an elevation of 12,500 feet above the sea, built by American engineers and opened to traffic in 1874. More recently the Antofagasta and Bolivian railway, starting from the Chilean port of Antofagasta, has pushed across the Andes and onward through the great Bolivian table-land to Oruro, only 139 miles from La Paz, the capital of the republic. The total length of this line is 574 miles. and it is now being extended to La Paz, while a branch from Uyuní to the famous silver region of Potosí, a distance of sixty miles, is under survey. It was built primarily to serve the needs of the Huanchaca of Bolivia Silver Mines Company and was very cheaply constructed, the gage being thirty inches and the track being laid with 36-pound steel rails. A very considerable commerce, however, has taken advantage of the facilities it offers, the traffic movement in 1892 having been 416,166 tons of freight and 21,741 passengers, yielding a gross income of $1,235,316, or $2152 per mile. The operating expenses amounted to $804,847, leaving a net income of $430,469.

The Peruvian group of railroads consists of a number of completely-isolated lines, aggregating 1127 miles. The Southern railway, by means of steamboat connection across Lake Titicaca, attracts considerable Bolivian traffic, and its northern branch to Sicuaní, which is being extended on to Cuzco, will ultimately form part of a system traversing the great central plateau.

During 1893 the famous Lima and Oroya (Central) railroad, with which Henry Meiggs, of the United States, was at one time connected, was completed as far as Oroya across the western chain of the Andes. The summit level of this remarkable road is 15,645 feet above the level of the sea, and throughout its whole length many difficulties of construction have been overcome by the genius of American engineers. It has now reached the silver-producing region and will be pushed on to the world-famous mines of Cerro de Pasco, but this is only a small part of its value to Peru. It has broken the great barrier which lay between the fertile, well-watered *montaña* and the arid western coast. From this time we may expect a steady growth of agriculture which will render Peru independent of foreign markets for her staple food supplies. Consequently we may anticipate the expansion of a railroad system throughout the *montaña*, which will bring to the Central railroad an enormous traffic.

With a few exceptions all the Peruvian roads are under the direct management of the Peruvian Corporation, Limited,—which has assumed the entire national debt of the republic. When they were handed over by the state, in 1889, they were in a wretchedly dismantled condition,—the result of the Chilean invasion and the subsequent poverty of the country. Most of them were being operated at a loss, due to poor equipment, poorer management, and official corruption. Their tracks have now been repaired, their rolling-stock improved and increased, and, under prudent management, they returned a net income in the fiscal year ending June 30, 1893, of $487,094. This is only the beginning of a prosperity which will equal if not surpass that of the most productive roads in South America.

Little need be said of the railroads in actual operation in Ecuador and Colombia, since they serve, not to control and create commerce, but as mere adjuncts to water and mule transportation. Venezuela has scarcely passed beyond this condition, although the Central railway, from Carácas toward the east, and the Tucacas-Barquisimeto line bid fair to aid largely in the development of the country.

Returning to the south, it must be noted that Uruguay, a state only nine times as large as Massachusetts, has an excellent system of about 1000 miles, penetrating the country in every direction,—from Montevideo to the Rio Uruguay on the west, and to Brazil on the north. Paraguay has 155 miles of railroad, which are being operated at a trifling profit.

Taking a comprehensive view of the railroad situation in South America, the most notable and instructive circumstance is that isolated, port-feeding lines do not pay and do not develop the resources of the country, while *systems* of roads do pay, and develop commerce, and stimulate diversity of occupations on the part of the people. There are of course some important exceptions, such as the Nitrate railways of Chile, whose returns average about $7000 per mile per year, and whose operating expenses are less than 35 per cent. of the receipts, and the La Guayra and Carácas railway, whose receipts are $20,000 per mile per year, with operating expenses at 74 per cent., but these anomalies are explained by peculiar local conditions. An exception may be found in the case of systems, also, where the Uruguayan railroads, as a group, are barely paying expenses, although some of these are doing well and all show a steady increase of traffic. The next notable circumstance is that railroads enjoying a government guarantee of interest do not pay so well as private unguaranteed lines. The cause of this would seem to be due in part to careless management, resulting from the indifference of stockholders who are content with their guarantee, and look askance upon outlays for improvements, the returns from which are more or less problematical. The interference of government is also a potent factor in reducing their profitableness, since modifications of tariffs and wages can be made only with the consent of officials, which is often difficult to obtain and always involves delays, so that the companies cannot promptly meet emergencies when these arise. Furthermore, such railroads almost invariably are bound by contract to revert to the government, after periods varying usually from forty to sixty years. This naturally discourages heavy expenditures upon permanent way and rolling-stock, so that the efficiency of the road is almost always limited by these unfortunate conditions. A system of state aid to encourage railroad-building, which seems to promise better results, has been adopted in Colombia, whereby interest-bearing bonds, receivable for customs, are issued by the government to railroad companies in certain sums for every mile of track actually constructed. A third circumstance is that roads owned and operated by the state are never so profitable as private lines handling an equal amount of traffic, and without exception there is an abnormal deterioration of track and equipment under state management.

In round numbers, there are about 19,000 miles of railroad in South America, of which more than 75 per cent. yield a net profit above operating expenses. There is consequently no little encouragement for the construction of new lines, and, while the reckless rush for concessions has ceased, there are many projects under consideration which promise to serve a useful purpose. In Brazil the progressive Mogyana Railroad Company, a Brazilian corporation, is pushing its line northward and westward from the state of São Paulo toward Goyaz,—a rich but isolated state which this road seems destined to control. This may lead in time to a trans-Brazilian line reaching Cuyaba, near the Bolivian frontier. There is also a project for extending the São Paulo system across to Paraguay, which has evident merit, and which probably will be accomplished if colonization continues in that republic. In Argentine the Corrientes line, east of the Rio Paraguay, contemplates making through connection between the Uruguayan and Paraguayan roads, which will give a powerful impulse to the development of this whole region from Asuncion to Montevideo. Mr. Frank Parish, one of the greatest Argentine railroad magnates, is now planning a network of roads, aggregating 770 miles in length, intended to develop the valleys of the Rio Colorado and the Rio Negro in that republic, making them tributary to the Argentine Great Western railroad. Renewed efforts are being made to extend the National Central Northern railway from Jujuy to Potosí, in Bolivia, a distance of 300 miles, where it will connect with the branch of the Antofagasta and Bolivia railroad now being located. Thus will be established a second transcontinental route, which will shortly have an alternative outlet to the Pacific coast by the Southern Railway of Peru, there being two projects on foot for a connection between Puno and La Paz, and the construction of the Antofagasta and Bolivia road being now in progress between La Paz and Oruro.

The purpose of the Chilean government to promote the further paralleling of the coast toward the south has been previously mentioned. The Central Railroad of Peru, according to the contract of the Peruvian Corporation, Limited, must soon be completed to navigable water on one of the Amazonian tributaries. The Pacasmayo and Magdalena railroad is to be continued to Caxamarca, the Chimboté line will soon develop the mineral and agricultural resources of the remarkable valley behind it, and the project for extending the Payta and Piura road to navigable water on the Amazon is again receiving deserved attention. In Ecuador the line from Guayaquil to Chimbo is to be built across the cordillera to Riobamba, and thence to Quito. The government, taught by the failure of previous contracts, will insist upon ample guarantees of good faith in the fulfillment of the new contract.

ENGINEERING SOCIETY SCHOOL OF PRACTICAL SCIENCE

The railroad development of Colombia is just beginning. An American company is building a line from Buenaventura on the Pacific to Cali in the Cauca valley, which will thence extend southward to Popayá. It is a most important line, contemplating a development of one of the richest regions in South America. The future growth of railroad systems in Colombia must be chiefly north and south, following the trend of its great valleys, and the Cauca railroad will be one of the most important parts of this system. The Antioquia railroad, starting from Puerto Berrio, on the Rio Magdelena, is also under construction and will ultimately extend into the upper Cauca valley. The Cartagena and Magdalena railroad, which is intended to divert the traffic of the Magdalena through the port of Cartagena, and which will be in operation by June 1, 1894, is another important North American enterprise wisely conceived, and destined to promote the growth of a great north-and-south trunk-line terminating at this magnificent land-locked harbor.

It is hardly necessary to mention those projects which rest so manifestly on a romantic basis that capital will never hazard so much as may be necessary to make preliminary surveys, such as the Pernambuco (Brazil) to Valparaiso (Chile) grand trunk-line, the Buenaventura to Bogotá (Colombia) transandine road, and the Araguaya (Brazil) mixed rail- and water- route from Goyaz to Pará. The proposed military road from central Chile across the deserts to the northern provinces could find no warrant on any but a military basis for its construction.

There are some plain destinies, however, which we are certain to see worked out, slowly it may be, and it may be as swiftly as the mountain-bastioned table-land of Bolivia has been rendered accessible to the world. Brazil must have a coastwise trunk-line, and a second running east and west to the valley of the Paraguay. It will not be long before the separate systems of Argentine, Chile, Bolivia, and Peru will be connected into one. Finally, the growth of the Colombian and Venezuelan roads will create a system developing the Caribbean-coast region and extending southward into Ecuador and Peru.

One serious disadvantage which will be felt more keenly as the present systems form connections with each other is the bewildering diversity of gage prevailing, not only in different parts of the continent, but throughout each separate state. In Argentine are gages of 5′6″, 5′5″, 4′8½″, 3′, and 1 meter. In Brazil conditions are still worse, the variety being 5′3″, 3′6″, 3′1¼″, 2′11½″, 1 meter, and .95 meter. As an example of the obstacles which traffic will encounter from this cause, the connection from Argentine through Bolivia to Peru will be accomplished through the National Central Northern 1-meter gage, the

Antofagasta and Bolivia 30-inch gage, and the Southern Railway of Peru 4'8½" gage. This evil is common to all new countries, but South America seems to be singularly afflicted in this particular. There can be no doubt that any sort of a tramway would be a hundred per cent. better than a mule, and this consideration may warrant the construction of many flimsy, narrow roadways, but where an expensive permanent way is contemplated future railroad-builders would do well to secure legislative action fixing a standard gage, to which all subsequent mileage in that state must conform, and the sooner an international agreement on this question is reached among the South American republics the swifter and more steady will be their development.

The river systems of South America have hitherto played an inferior part in the acceleration of commercial progress, but they will become factors of the greatest value upon the extension of railroad systems. In the north, the Orinoco and its giant tributary, the Rio Meta, afford 900 miles of east-and-west navigation, extending to within 125 miles of Bogotá. At a distance of eighty miles to the westward of Bogotá is the Rio Magdalena, navigable southward from the Caribbean sea for 600 miles. Here is a great triangular region, bounded by the Orinoco, the Magdalena, and the Caribbean, having an area of 1,000,000 square miles, no point in which is farther than 150 miles from water communication,—a circumstance which, combined with its wonderfully varied resources, will make this one of the most favored portions of the globe, with transportation charges so low as to encourage enormous production. The valley of the Paraguay, navigable 2400 miles northward into Brazil, with its floods sweeping past the great commercial center of Argentine, must exert a powerful influence upon the development of the heart of the southern continent. The function of the Amazon will apparently be less important. It cannot economically be paralleled by railroads. It will continue to serve as an outlet for certain products from the eastern portions of Bolivia, Peru, Ecuador, and Colombia, and, as these sections are traversed by railroads, it may regulate freights upon them to some extent. The Pacific ocean is the competitor which will cheapen freights and favor the growth of a railroad system on the western coast; the Rios Magdalena and Orinoco, with the Caribbean sea, constitute the guarantee of large prosperity for the northern portion of the continent; while the Rio Paraguay promises to be the scene of commercial activity rivaling that of Argentine and of São Paulo in Brazil, as soon as sluggish water transportation shall be supplemented by the facilities of railroads.

There are many reasons why American capital and American engineers should enter these promising fields. In the southern continent opportunities are afforded for the exercise of that rare ability which our people have shown in opening up virgin lands. We have developed the most scientific and most economical railway practice in the world. This skill and knowledge brought to bear upon South America will soon fill the continent with the bustle of industrial activity, and create an ever-growing market for the surplus products of our labor.

Even to-day we might reach a richer harvest than we do. It is very generally recognized that American rolling-stock, on account of its lightness and strength, and its adaptability to curves of short radius, is superior to any other for use on the majority of the South American railroads. In consequence of this many British and European manufacturers advertise "American" equipment, modelled after patterns prevalent in the United States. When it is considered that in many cases the equipment is subject to government approval, and that the recommendation of American types is met usually by the substitution of foreign imitations, it is evident that an unworked field exists in South America for our manufacturers of cars and locomotives. But we cannot hope to sell largely to new countries while our capital stands aloof from the development of their resources. An order for merchandise is truly a "favor," as merchants say, but in the great balance of trade these "favors" are found to be reciprocal to a large extent. Invested capital can determine the commercial intercourse of nations, and, if we would insure our participation in the benefits of this growing southern commerce, we must aid in the expansion of routes of communication in South America wherever the visible traffic is sufficient to sustain them.

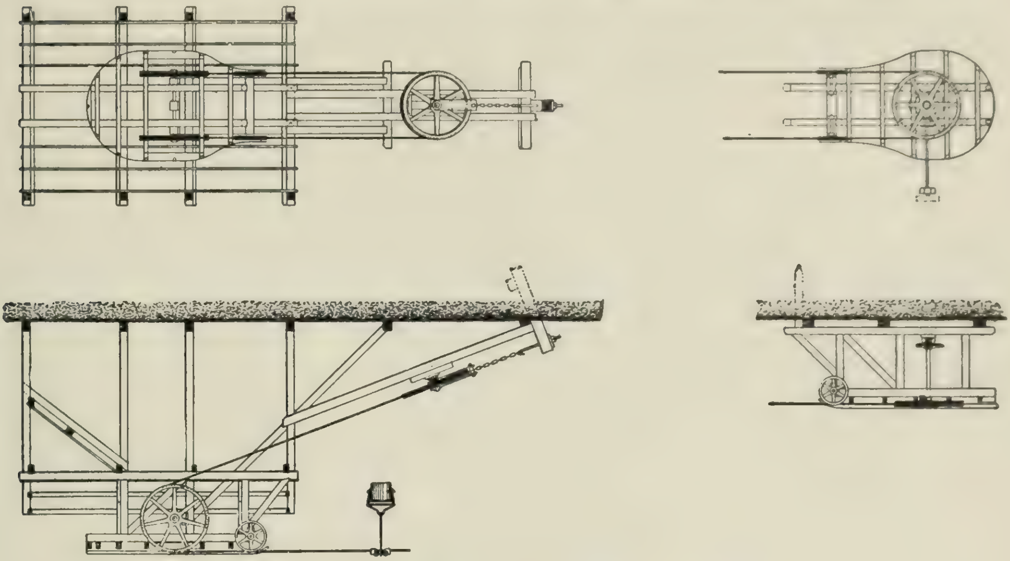
TRANSPORTATION BY WIRE-ROPE TRAMWAYS.

By William Hewitt.

THE application of wire rope to purposes of economical transportation, in the shape of aërial tramways, has opened up such wide possibilities in mining and other operations that some account of the different methods and of the progress made of late years in this peculiar branch of engineering can hardly fail to be of interest. The idea of conveying materials by means of suspended wire ropes is not by any means new, but has long been an attractive one, especially to miners and quarrymen, as it avoids the long and costly detours which, in most mining sections, would be necessary in any kind of surface road. At first glance it would seem to be a simple problem, but, like everything else in engineering lines, considerable thought and ingenuity have been expended in its development, and it was many years before this method of transportation could be depended on for anything but the lightest kind of service, and then only under favorable conditions.

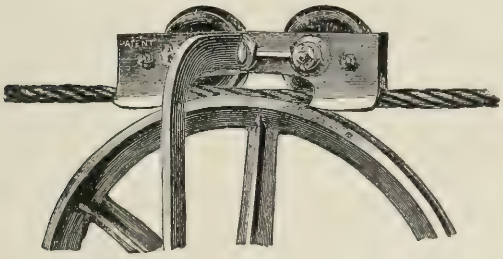
The first instance of aërial transportation of which we have a record appeared in 1855, when Mr. Peter Cooper constructed a line at Ringwood, New Jersey, for carrying ore from the mines to the blast-furnace there. The line was operated by gravity (the fall being sufficient for this) and consisted of an endless ⅜-inch wire rod, running over grooved sheaves and around large terminal wheels. To this rod were suspended a series of buckets by means of curved pendants or hangers, the tops of which were fashioned in the form of a gooseneck, in order to clear the flanges of the supporting sheaves. Wire rope at this time was unknown, or at least had not come into general use.

With the advent of wire rope, however, it was not long before its adaptability to aërial transportation was recognized. The first application of the kind appears to have been made by John A. Roebling, for transporting coils of wire in the construction of his suspension bridges. The pioneer in this direction, however, to whom most credit is due, is Charles Hodgson, of Richmond, England, who obtained letters patent in 1868 for "an improved means of an apparatus for transporting loads," in which he describes two modifications of his invention. In the first, which he designated as the "fixed-rope" system, the loads were suspended from trolleys or "running blocks," as he calls them, traversing a pair of stationary ropes, and propelled by means of an endless moving rope, to which these blocks were attached—a modification which has since been developed and perfected by Adolph Bleichert, to whose improvements we shall refer at length later on. The second modification, which he describes as the "single-rope" system, consisted simply of a single endless moving rope, serving to both support and convey the loads. Although the "fixed-rope" system was the first to be described in the patent referred to, and the first one to be experimented with, in the subsequent development of the invention it was abandoned, principally on account of the difficulty of getting suitable materials for the "running blocks," and all improvements were directed to the second or "single-rope" system, which is now the one commonly associated with Mr. Hodgson's name.



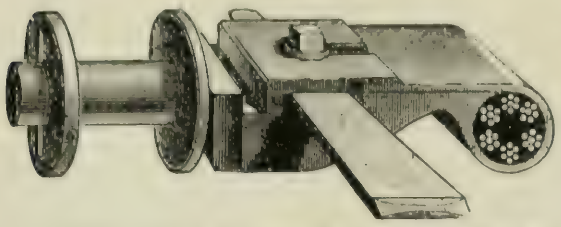
TERMINALS OF SINGLE MOVING-ROPE TRAMWAY.

The "single-rope" system in its experimental stage was virtually the same in conception as that embodied in Mr. Cooper's tramway at Ringwood. The details may have been a little more carefully elaborated perhaps, but the only radical difference was in the employment of a wire rope in place of the traveling rod which Mr. Cooper used.

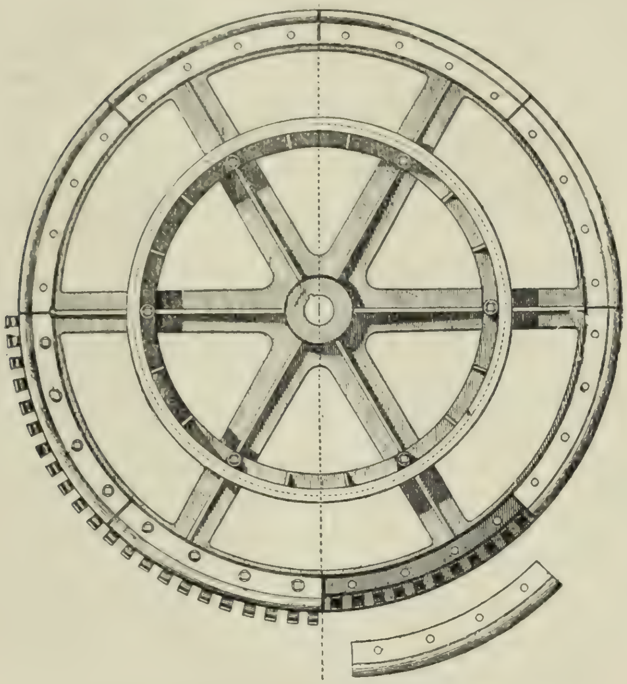


BOX-HEAD CARRIAGE FOR SINGLE-ROPE TRAMWAYS.

Mr. Hodgson succeeded in interesting Messrs. Bullivant & Co. in his invention, and a number of prominent Englishmen, among whom may be mentioned W. T. H. Carrington and E. G. Spilsbury. An experimental line was built on one of the downs in southern England, and, like most ventures of the kind, was a failure at the outset, as far as its practical operation was concerned. But it served the purpose for which it was built, and, after undergoing many alterations in the various details, the practicability of the thing was at last satisfactorily demonstrated, and a company was organized, known as "The Hodgson Wire Rope Tramway Company." A number of lines were built by this concern in various quarters of the globe, some of which were from ten to twelve miles in length, and one in particular was a very elaborate affair, being no less than a series of three lines, mounted upon the same standards, one above the other, and aggregating about thirty miles in length. Most of these lines were very satisfactory in their operation, others only indifferently so, and a few were absolute failures. With the panic of 1873 the Hodgson company collapsed, and the building of these lines has fallen into other hands.

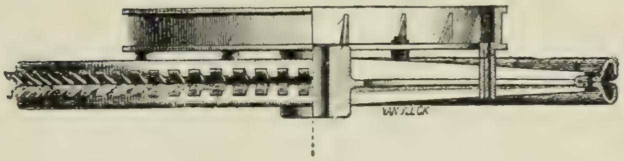


HANGERS FROM WHICH BUCKETS DEPEND IN HALLIDIE TYPE OF ROPE-WAYS.

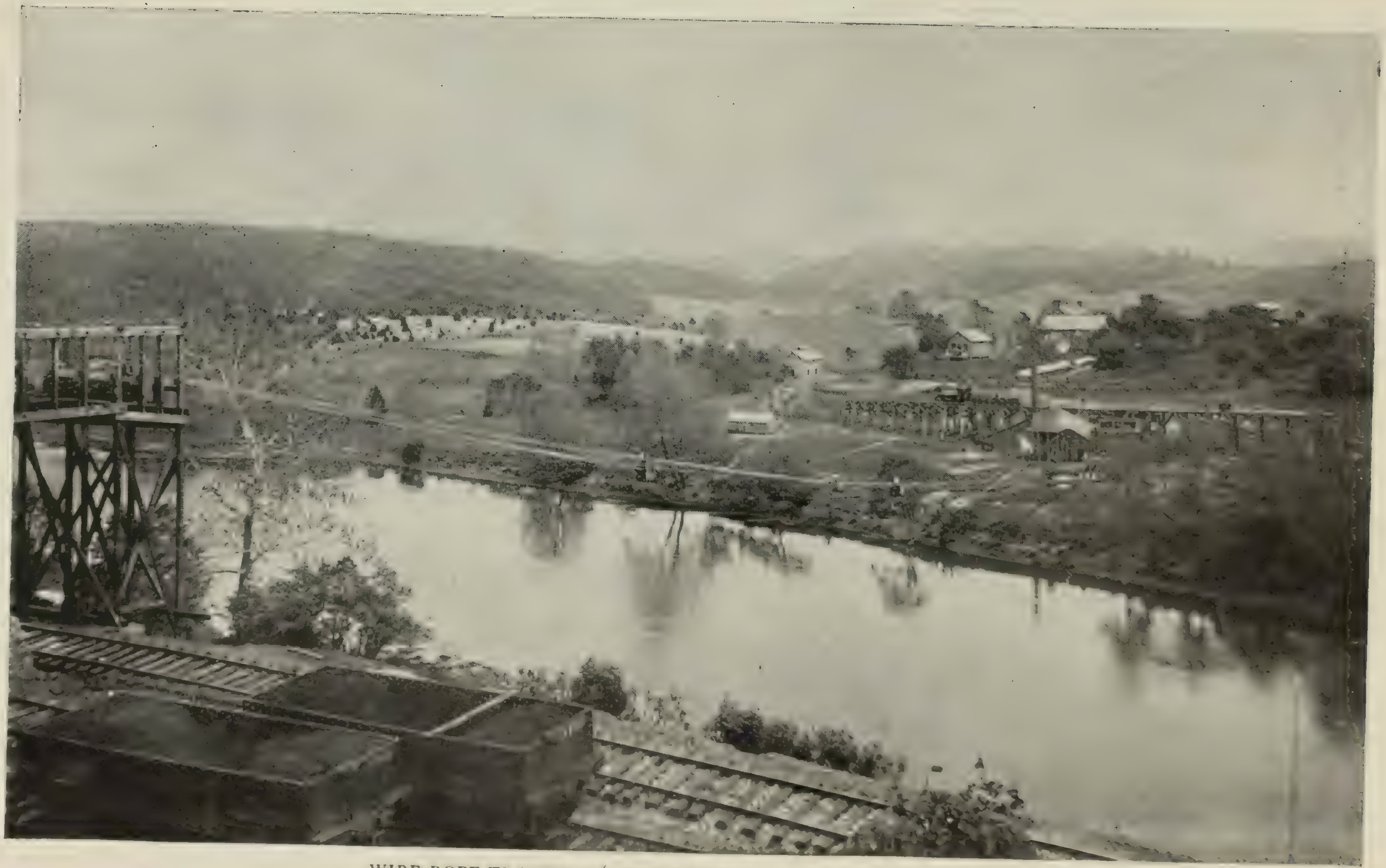


GRIP PULLEY, WITH BRAKE WHEEL.

It is an important consideration, in any apparatus of this kind, to have everything as light as possible, consistent with the necessary strength, and one of the chief difficulties at the outset was to get suitable materials, as we have already stated. Cheap steel, and especially the higher grades of mild-tempered steel such as are now used in the construction of



SECTIONAL PLAN.



WIRE-ROPE TRAMWAY (ACME SYSTEM) AT IVANHOE, VIRGINIA.

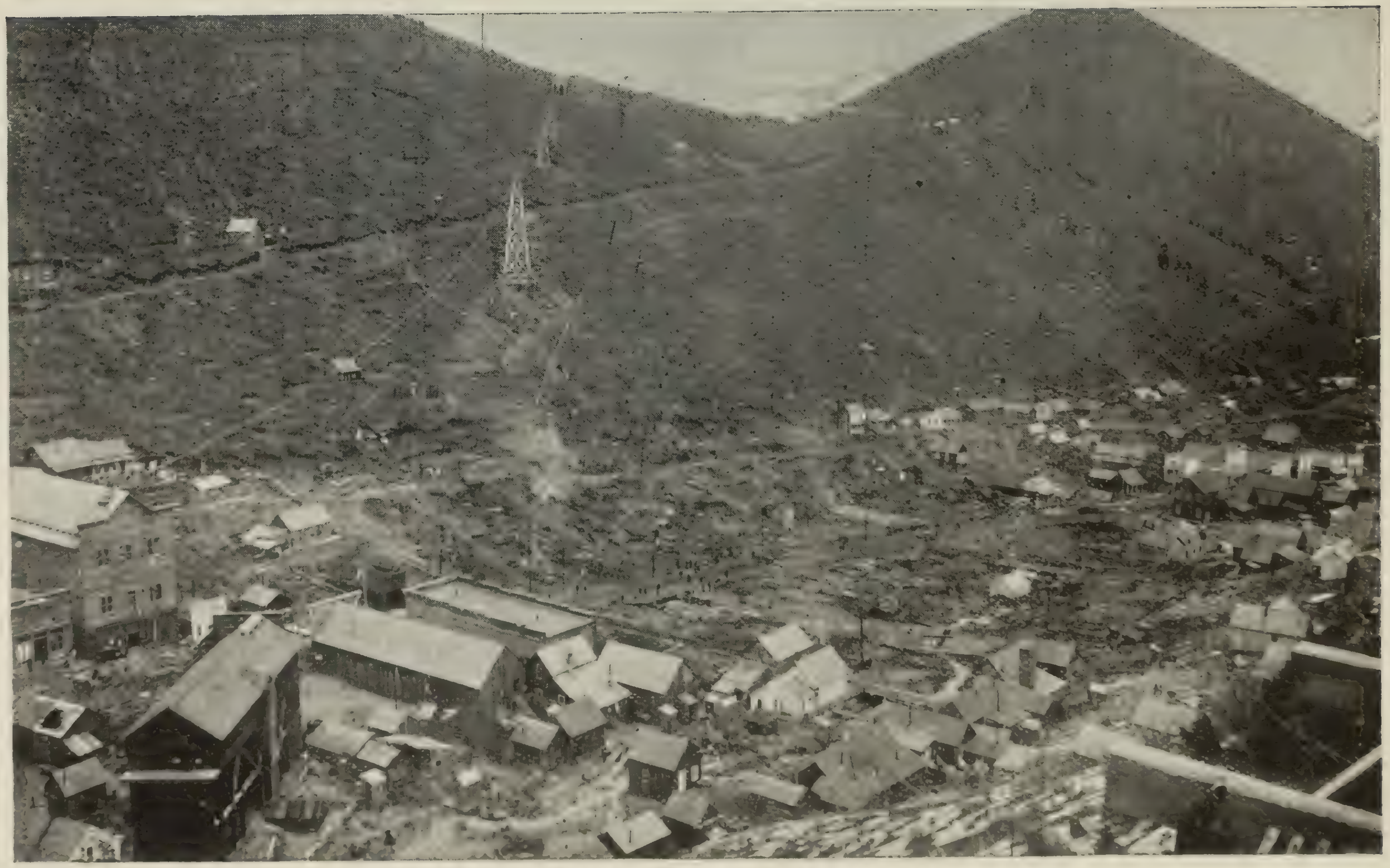
[Plant of the Pennsylvania Zinc and Iron Company.]

WIRE-ROPE TRAMWAY (BLEICHERT SYSTEM).
[Old Dominion Copper Company, Globe, Arizona.]

wire rope, were then unknown. Everything had to be of cast- or wrought-iron. The structure in consequence was very clumsy, and this proved to be a serious drawback to the successful operation of many of the earlier lines.

One of the earliest in this country was a line built for the Mount Savage Fire Brick and Mining Company, by Mr. E. G. Spilsbury, who was then the American representative of the Hodgson Wire Rope Tramway Company. Several other lines have since been built from Mr. Spilsbury's designs, among which may be mentioned one for the Juniata Sand Company, at Lewistown, Pennsylvania, which is still in successful operation. In some of the lines in this country, as well as in many of the foreign lines, considerable difficulty was encountered in the slipping of the box-heads on the rope, owing to the steep inclination at certain points, and it was found impracticable to work these lines over grades having a greater inclination than about 1 in 4.

The box-heads (or saddles) consist of light malleable-iron boxes, containing what are termed the "bearing-blocks," usually of rubber or wood. These are secured in such a way that they can be readily replaced as they wear out. Referring to an accompanying cut, it will be observed that the box-head is fitted with a couple of small grooved wheels at one side. The object of these is to free it from the rope at the terminals and other stations, and this operation is performed by providing rails at these stations, or flat bars suspended to the framework, the terminal points of which are bent down, and so placed as to



PORTION OF 1150-FEET SPAN OF WIRE-ROPE TRAMWAY, WARDEN, IDAHO.

[Plant of the Bunker Hill and Sullivan Mining Company.]

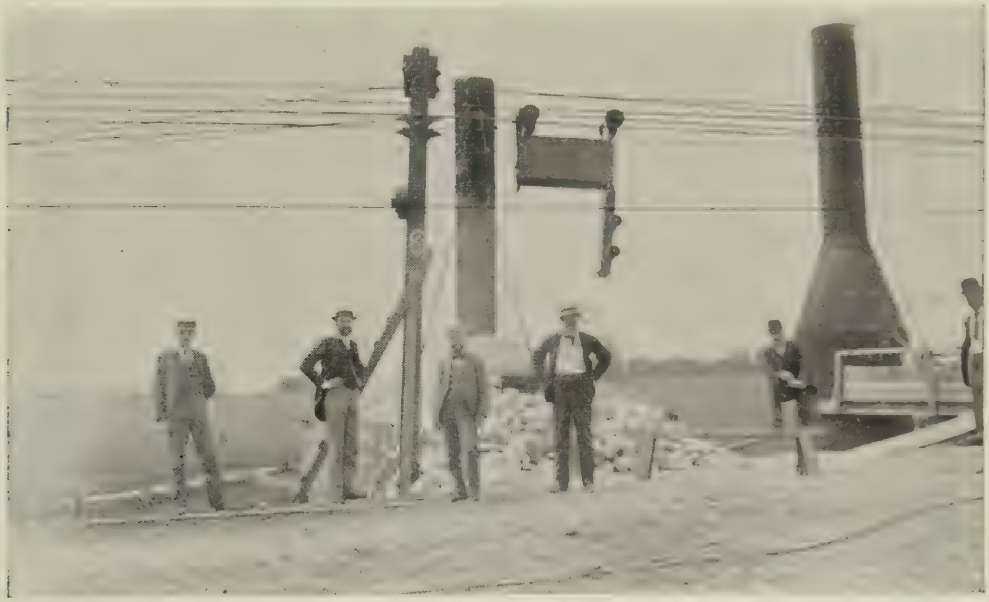
receive or engage these small wheels on the box-heads. The momentum of the buckets carries the box-heads up on to the elevated rail, and they are thence conveyed by hand to convenient points of loading or discharge, as the case may be, while the motion of the rope continues uninterrupted. The frictional contact between the "bearing blocks" and the rope is simply depended on to keep the "box-heads" in place along the line, and it is evident from this that the system is not adapted to very steep grades. Mr. Hodgson endeavored to overcome this defect by devices for gripping the rope.

It was about this time, or soon after the Hodgson system was introduced in the United States, that Mr. A. S. Hallidie, of San Francisco, became interested in this method of transportation, patented certain improvements, and introduced the system associated with his name. The distinctive feature of the Hallidie tramway is the manner in which the pendants or bucket-hangers are inseparably attached to the rope. For this purpose steel clips are used, of peculiar construction (illustrated in an accompanying cut), which ride freely over the supporting sheaves and around the terminal wheels. This occasions the necessity of loading and unloading the buckets at definite points while they are in motion, in consequence of which these lines can only be run at a very moderate speed,—in other words, about 180 feet per minute,—which requires a somewhat larger outfit of buckets than lines which admit of higher speeds.

WIRE-ROPE TRAMWAY (ACME SYSTEM).

[The Cedar Hill Lime Company, Port Kennedy, Pa. Length of Line, 1450 feet; Daily Capacity, 150 tons. Cut Shows How Cars are Loaded Automatically.]

A great advantage of these lines is that they can be operated over any grades, and for a certain fall in favor of the loads become self-acting; that is, the loaded buckets in descending develop sufficient power to haul back the empties, requiring the application of a brake at the operating terminal. The necessary inclination for this varies with the amount of material carried and other conditions, but usually is about 1 in 7. Where there is considerable excess of power developed, above the amount actually required to operate the line, this may be utilized in various ways. In all cases where the difference in elevation between terminals is very great, especially if the line is a long one, and either requires or develops much power, it is necessary to employ a grip-wheel at the operating terminal. It will be observed, from the cuts we present illustrating the construction of such a wheel, that the periphery or rim is fitted with a continuous series of steel jaws, which operate in pairs on the toggle principle, and, under pressure, with sufficient force to prevent the rope from slipping. The moment they are relieved of this pressure the jaws open and allow the rope to pass off freely.



WIRE-ROPE TRAMWAY (ACME SYSTEM).

[The Cedar Hill Lime Company, Port Kennedy, Pa., Cut Shows How Stone is Deposited at Kilns.]

To obviate the objectionable feature of having to load the buckets while in motion, automatic loaders have been introduced, the most ingenious and best of which is the patent device of Charles M. Huson, of Denver, consisting of a hopper which travels with the bucket in the act of loading, and returns to its original position at the bin after each bucket is loaded.

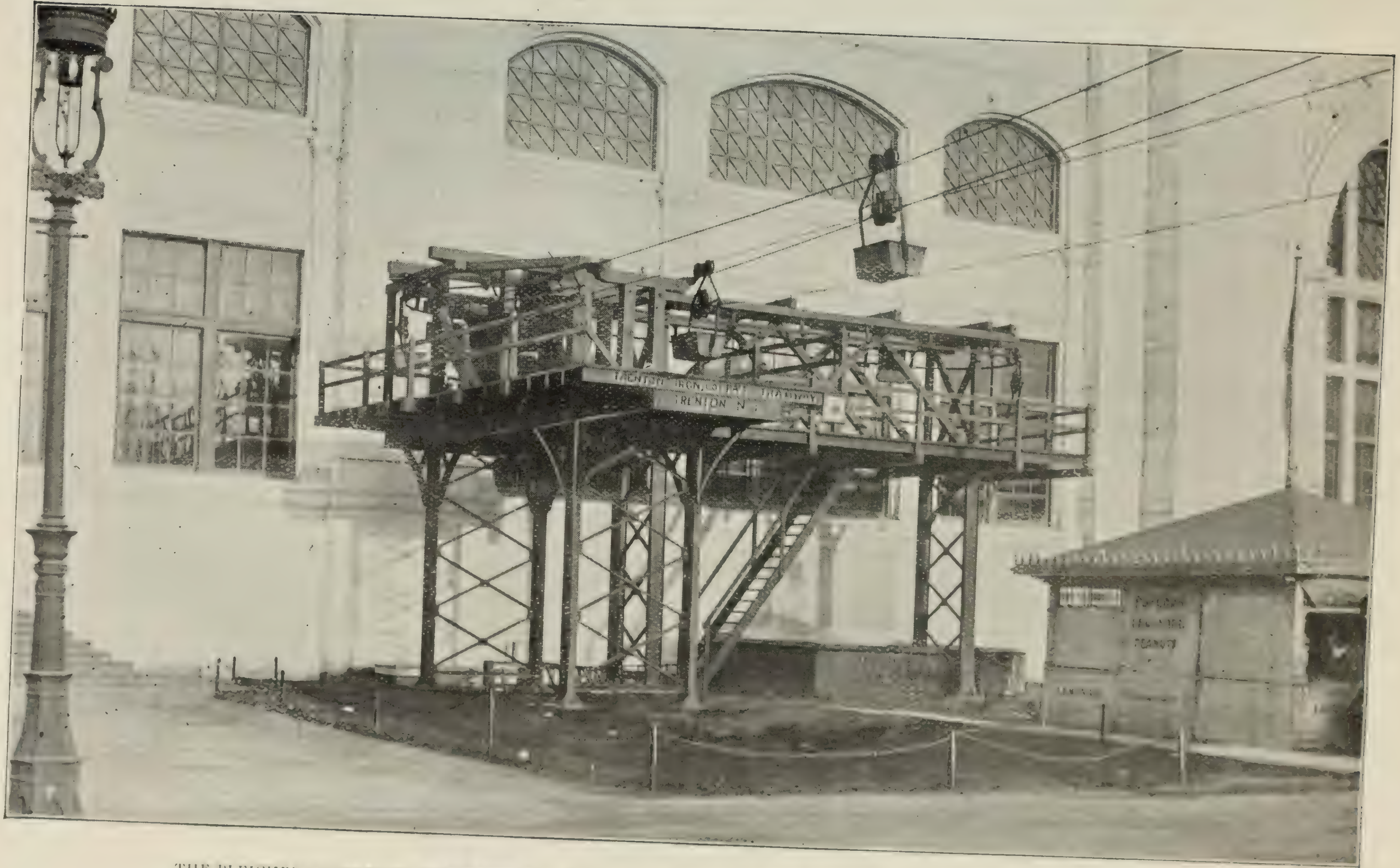
All of these single-rope tramways, whether of the Hallidie or the Hodgson types, are, from the nature of their construction, limited to the carrying of comparatively light loads, and their application therefore has been confined to the transportation of materials where the output is correspondingly light, although in a few instances, where the conditions have been favorable, heavy loads have been carried.

A system has been introduced, known as the Pickett system, in which conveyance is effected by means of two endless ropes running parallel to each other around large vertical sheaves at the terminals. The buckets are inseparably attached to these ropes, the loaded ones riding the top lines, dumping their contents in passing around the sheaves at the discharge terminal into a hopper or bin, and returning inverted on the under portion of the ropes, like the buckets of a chain conveyor. The objection to this system arises from the irregularity of the motion of the two ropes, due to uneven wear in the sheaves, or uneven stretching of the two ropes, causing the buckets to assume a skewed position,—an objection which does not hold to a chain conveyor, owing to the nature of its construction. It is not to be inferred from this comparison, however, that a chain conveyor is to be preferred, as such appliances are applicable only to very short hauls, and are not adapted to the transportation of materials for long distances.

With the vast improvements of late years in the manufacture of steel has been inaugurated a new era, surpassing in its realizations the fondest hopes of its creators. Improvements in the art of tempering,

SINGLE-ROPE TRAMWAY AT A PHOSPHATE-MINE.

[Empire State Phosphate Company, Rock Mines, Florida. Showing Portion of Cableway Used for Hoisting and Conveying the Rock from Quarry to Bins.]



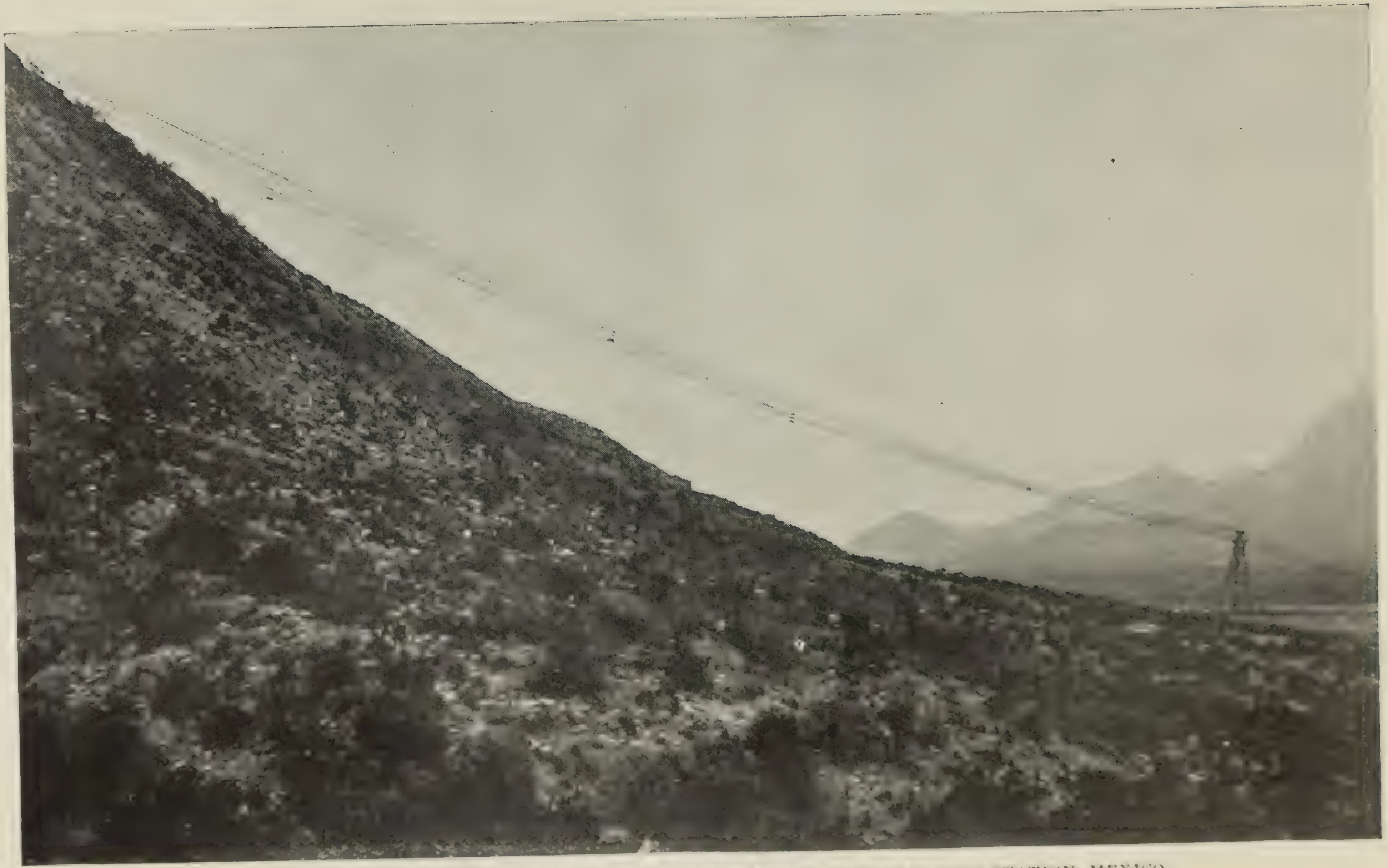
THE BLEICHERT IMPROVED WIRE-ROPE TRAMWAY—EXHIBITED BY THE TRENTON IRON CO. AT THE WORLD'S FAIR.

especially, have led to the introduction of a peculiar grade of cast-steel wire, possessing a high tensile strength combined with a certain degree of ductility, and, where it was formerly necessary to employ a rope weighing two pounds to the foot, we now use one weighing less than a pound. The possibility of obtaining light steel castings at a comparatively low price has also contributed much to simplify the problems connected with aërial transportation. Under these favorable conditions Mr. Adolph Bleichert, of Leipzig-Gohlis, Germany, has brought to bear upon the subject the skill of a thorough engineer combined with a wonderful amount of ingenuity, and has developed and patented a system of wire-rope tramways that has met with great favor, and was introduced in this country about five years ago by the Trenton Iron Company, under the direction of Mr. E. G. Spilsbury.

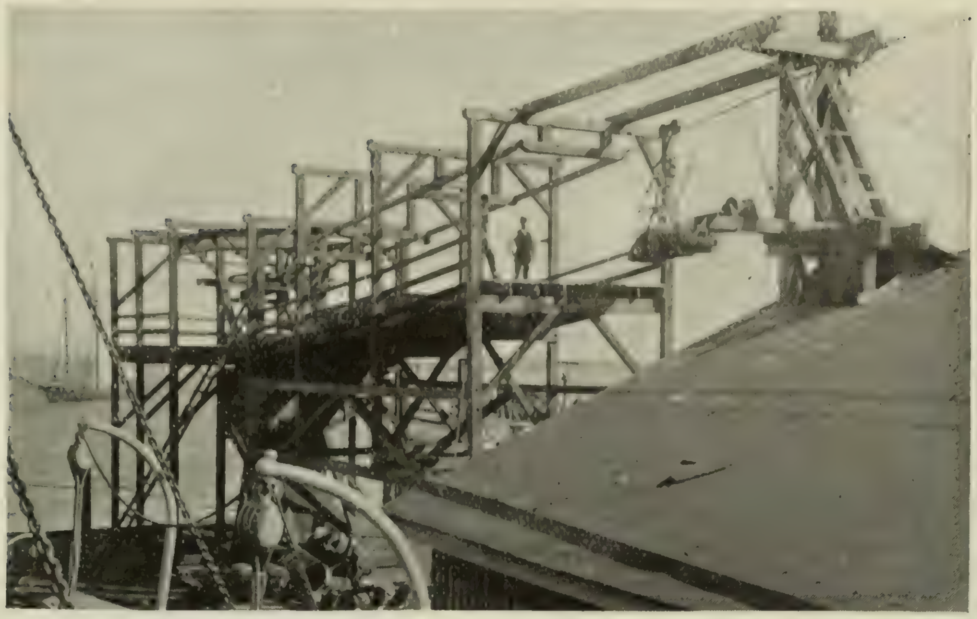
In its general design it is similar to that first described by Mr. Hodgson as the "fixed rope" system; that is, the buckets are suspended from trolleys or carriages traversing stationary cables, and are propelled by means of a light endless traction rope, to which they are attached by grips of peculiar, very simple, and exceedingly ingenious construction. Loads up to half a ton and over may be carried in this way, and it is possible to transport by a Bleichert tramway as much as

INTERIOR VIEW OF DISCHARGE-TERMINAL.

[Wire-Rope Tramway (Bleichert System) of La Gran Fundacion National Mexicana, Santa Catarina, Mexico.]



WIRE-ROPE TRAMWAY OF LA GRAN FUNDACION NATIONAL MEXICANA, LEON STATION, MEXICO.



DISCHARGE-TERMINAL OF WIRE-ROPE TRAMWAY.

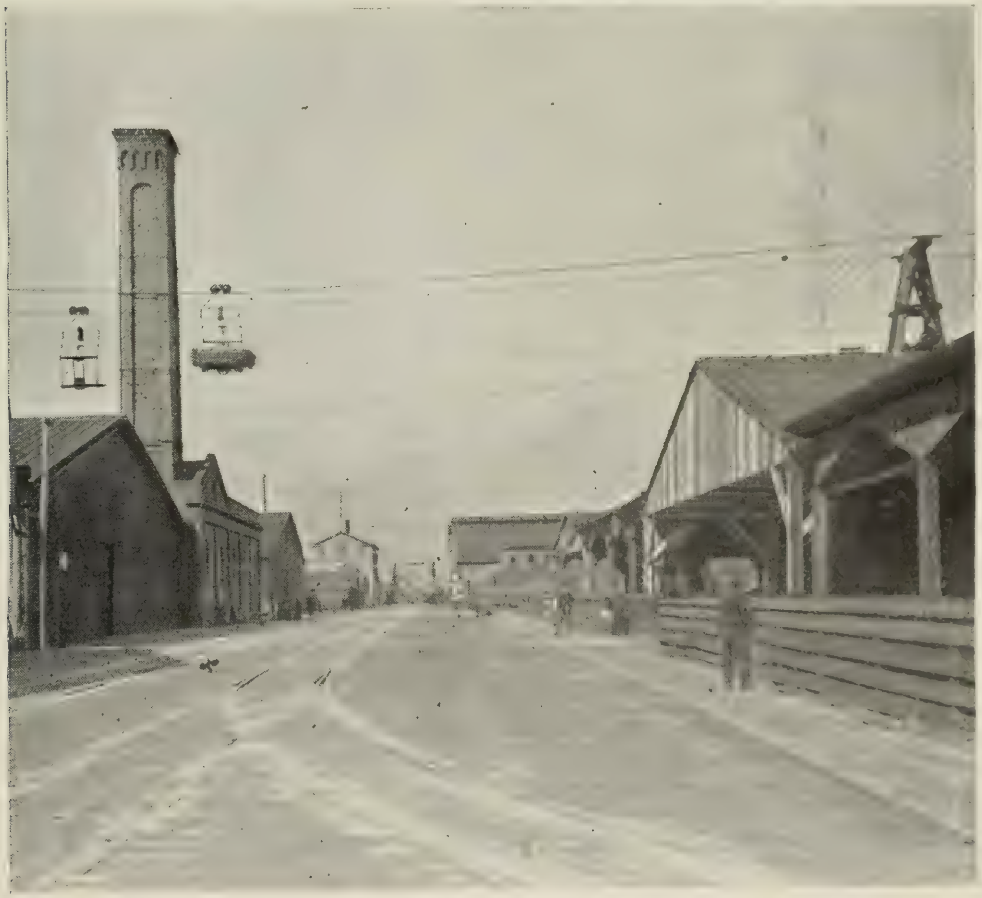
[Plant of East Shore Terminal Company, Charleston, S. C. View of Charleston Harbor in the Background.]

80 and even 100 tons per hour. The advantages of these lines have been so well appreciated abroad that railroad companies have adopted them as regular feeders to their main roads.

The details of the system have all been very carefully worked out with a view to reducing the wear of the moving parts as much as possible. The carrying cables are of special construction ; and, in the "smooth-coil" cable introduced by Bleichert, the wires are laid up in such a way as to present a smoother surface than in ropes of the ordinary lay, and are larger, which adds not only to the life of the cable itself but also to that of the rolling-stock. But the best cable unquestionably is that introduced recently, known as the "patent interlocked carrying cable," from the fact that the outer wires are drawn or rolled to shape and laid up in such a way that they interlock one with the other, presenting a perfectly smooth surface, and possessing sufficient flexibility to be shipped in coils. This type of cable gives the highest degree of service, with a minimum amount of wear in wheels.

These cables are usually anchored at one end of the line, and weighted at the other to the proper tension, by means of boxes filled with stone or other suitable material, and the strain upon them, if the cables are kept properly greased, is governed almost entirely by the amount of weight so applied, being independent of the loads carried, provided these are not so great as to cause the cables to sag beyond the range of movement of the counterweights. This is not likely to happen, even where there is ample room for the deflection of the cables corresponding to any load, if the weight-boxes are properly hung, as any great difference in deflection produces a comparatively small movement of the weight boxes, and the strain on the carrying cables therefore is practically uniform.

During 1893 several lines were built that were remarkable for their long spans. The line of the Susquehanna Water Power and Paper Company crosses the Susquehanna river, at Conowingo, Maryland, about ten miles above Havre de Grace, and consists mainly of two long spans each 1700 feet in the clear, the central support, which is 100 feet high, being located upon an island in the river. The line is used for conveying coal and supplies from the Port Deposit branch of the Pennsylvania railroad, on the east side of the river, to the mill on the west side, and also for taking paper over from the mill to the railroad. Another line, at Guanacevi, Mexico, about 1¼ miles in length, for conveying silver ore from the Wilson mines, has in it one clear span of 1350 feet. An interesting line is that of the Penn Glass Sand Company, of Emlenton, Pennsylvania. It is used to convey sand for glass-

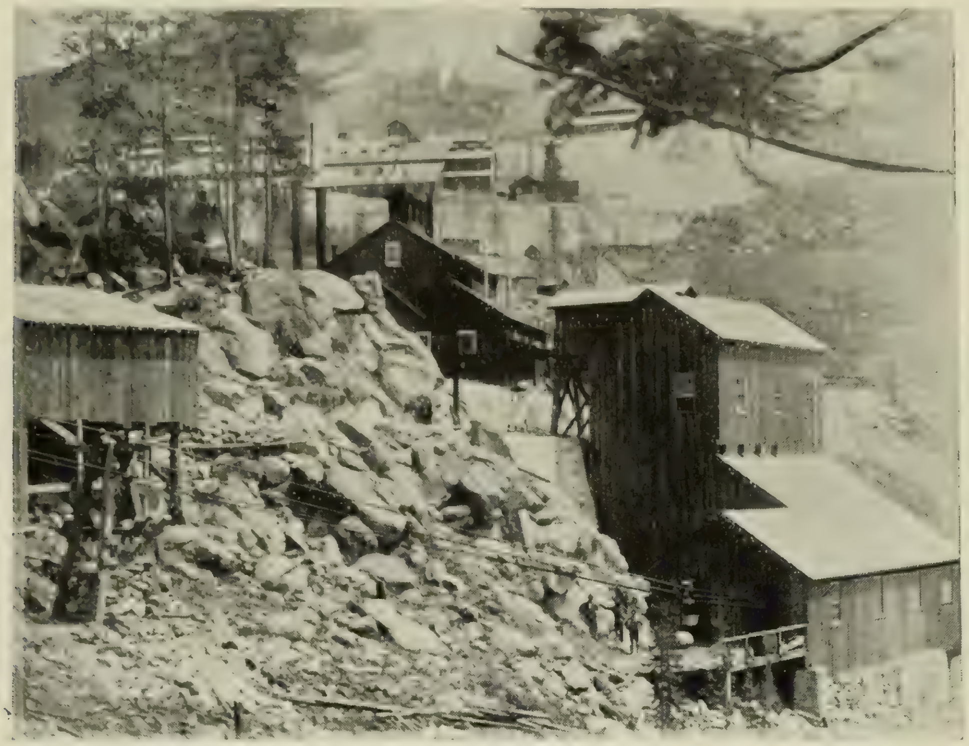


WIRE-ROPE TRAMWAY (BLEICHERT SYSTEM).

[The East Shore Terminal Company, Charleston, S. C. Length of Line, 700 Feet; Daily Capacity, 500 Tons.]

making purposes from mines in Venango county, Pennsylvania, to the works of the company, a distance of about a mile. The mines are on the west side of the Allegheny river, and the mill is on the east side, alongside the main track of the Allegheny Valley railroad at Scrubgrass, near the station of Kennerdell. The span across the river is 1100 feet, and the main cable upon which the loaded cars travel is of the patent locked-wire type, 1⅛ inches in diameter.

Two lines were built recently for the United Concentration Company for the conveyance of gold-ore from mines in Snohomish county, Washington, to the concentrating-works of the company at Monte Cristo. The lines meet in a common discharge terminal at the bins of the concentrating-works. The longer of the two lines communicates with the Pride of the Mountains mine, and the shorter one with the Mystery mines. The Pride of the Mountains mine is located on the side of a steep mountain, and the line crosses a deep gulch known as Glacier Basin, a clear span of about 1400 feet, between this mountain and Mystery Hill. From Mystery Hill the line passes over a snow-slide on a very steep inclination, and thence to the mill, the total fall being about 1700 feet. The carrying cables from the loading terminal to the tension station on Mystery Hill are of the patent locked-wire construction, on both the loaded and empty sides.



WIRE-ROPE TRAMWAY FOR CONCENTRATING-WORK.

[Plant of Bi-metallic Mining Company, Granite, Montana.]

Both lines cross the snow-slide, in spans varying from 800 to 1000 feet. What few supports there are have been located at the most favorable points and protected from the snow by sheds. The accompanying illustration of the line of the Bunker Hill and Sullivan Mining Company shows a portion of a span of 1150 feet, where the line crosses the town of Wardner, Idaho. The line is 9000 feet long and has a daily capacity of 400 tons.

In the design of these tramways the practice is to lay out the line of the carrying cables very carefully for a given tension and erect the supports to this line. The cables, however, are actually weighted to a lower tension, so that these may not rise out of the saddles upon which they rest, which might happen if the applied weight corresponded with the curves regulating the height of the supports. Where the line is a very long one it becomes necessary to weight the carrying cables at intermediate points, in order to allow for friction, and preserve as nearly as possible a uniform tension throughout the line. Tension stations are introduced at such points, the construction of which is such as not to interfere in any way with the movement of the cars, and requiring no attendants. As a rule these are spaced from 4000 to 5000 feet apart.

The saddles upon which the carrying cables rest are made with curvatures of large radii, so that the carriages ride over them very easily, and there is no difficulty of maintaining speeds of three to four miles per hour. Taking this into consideration, with the fact that much heavier loads are carried than on the "single-rope" lines, the number of buckets required for a given capacity is only about one-third as great, making less to load and unload and reducing the wear and tear correspondingly.

One great advantage of these lines lies in the fact that any grades, no matter how steep, can be surmounted; and, in fact, there is no profile so rugged as to present insuperable difficulties in this respect. A precipitous rise or fall, for instance, presents no obstacle, since the cable lines can always be laid out so as to bring the inclination within the proper limit, which is about 45 degrees. Valleys and streams are crossed by long spans, as already explained. These points are well illustrated in the profile of the Granite Mountain Mining Company's line at Rumsey, Montana.

The construction of the grips for securing the cars to the traction rope is such that when the cars arrive at either terminal, or any station along the line, they are detached automatically and run off on suspended rails to any desired point of loading or discharge.

Various styles of grips have been used, some depending simply on frictional contact with the traction rope to hold them in place, and

WIRE-ROPE GRAVITY INCLINE, AALSUND, NORWAY.

others of a positive character, designed to straddle lugs secured to the traction rope at intervals regulated by the amount of material to be transported. The latter are preferred where steep grades occur. These lugs are made in halves, and are applied in such a way that they can be readily replaced by new ones or moved to other points on the rope from time to time, as circumstances may require.

The usual arrangement is to load from bins, but, if desired, the buckets may be transferred to special trucks, which traverse surface tracks. These trucks are designed to accommodate one, or, more commonly, two, buckets, and are run into the mine, quarry, or other loading point, filled at the face of working, returned to the tramway terminus, and sent over the line without any rehandling of the material. In some cases the buckets themselves have been fitted with wheels.

Special scales are employed for weighing the cars, and counters for registering the number of buckets transported. If desired, the cars may also be raised or lowered by elevators at either terminal; in fact, the system is very complete in all its appointments and can be adapted to meet almost any requirements where the loads are within what men can handle advantageously.

The cost of installation of a Bleichert line varies, according to the capacity and terminal requirements, from $8000 to $16,000 per mile. The cost of operation depends upon the output, price of labor, whether the line is automatic in its action or requires power, and other conditions, and ranges usually from 3 to 10 cents per ton per mile. Under ordinary conditions but five men are required : an engineer or brakeman, as the case may be, to operate the line, and two men at each terminal, one to attend to the loading or unloading of the buckets and the other to do the gripping. It is only in cases where the output is very heavy, where intermediate stations occur, or where there is much switching and handling of the buckets at the terminals, that more men are required. The cost of maintenance is also comparatively low, and as a rule will not exceed in a year 8 per cent. of the investment.

The line of the Split Rock Cable Road Company near Syracuse, New York, for instance, which is used for transporting lime-rock, is 16,500 feet long, and has a daily capacity of 750 tons. It passes over rolling ground, where the grades are moderate and long spans do not occur, the discharge terminal being but about 240 feet lower than the loading terminal. At the discharge terminal the rails extend over a long line of kilns, into any one of which, by means of a series of switches, the lime-rock is discharged. As a precaution against fire the entire superstructure over the kilns is of iron. The line has been in operation about four years, running night and day. During 1891, nearly 196,000 tons of rock were carried over it, at a cost of about 6 cents per ton per mile, covering all expenses, including, in addition to the labor and materials for operation and repairs, the expenses of right of way and taxes.

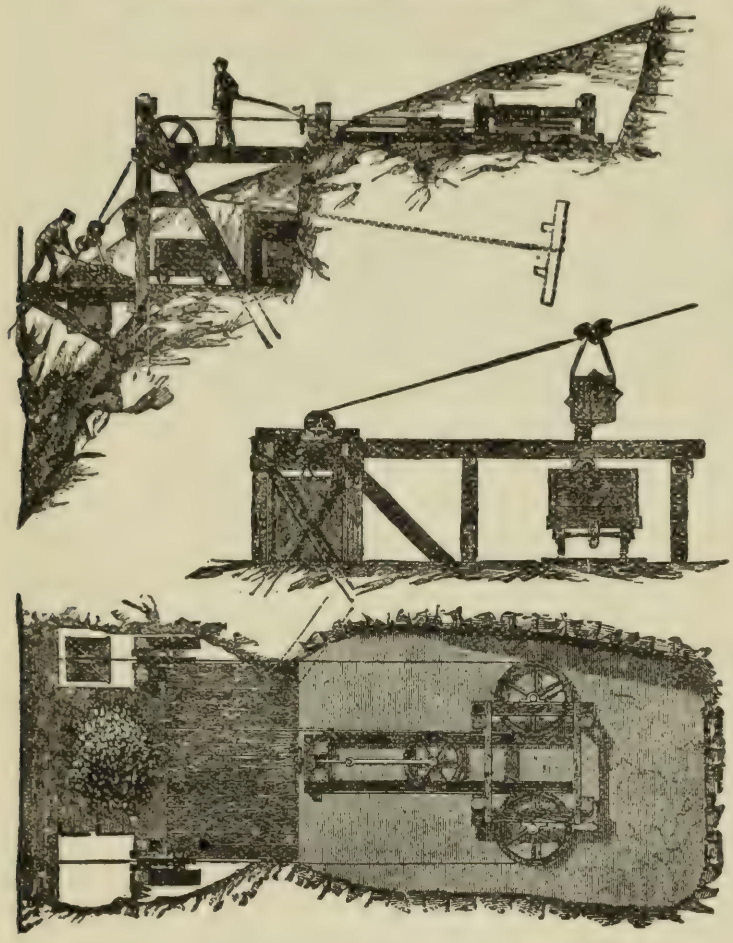
A very interesting exhibit of the Bleichert system was made by the Trenton Iron Company at the World's Columbian Exposition, a complete working line having been erected there, showing all the details of construction, and the various styles of cars used. This line ran from an elevated station adjoining the Mines building, over the intramural railway, to a point near the exhibit of the Pennsylvania Railroad Company. The line was kept in constant operation, being used at times to carry materials to the Mines building, while throngs of people were passing beneath it all the time, and was one of the features of special attraction.

The several views which are presented here of Bleichert lines will give a fair idea of the wide application of the system ; in fact, the number of these lines that have been installed now mounts up into the hundreds.

The different kinds of wire-rope tramways thus far described require the use of bins or other means of transferring the material to and from the tramway buckets, excepting in the case of the Bleichert system, where the buckets are transferred to special trucks, and even in this case the labor amounts to practically the same thing, and the only advantage derived is in the saving of material effected by not having to rehandle it.

Several systems have been devised for the conveyance of cars adapted to traverse overhead as well as surface tracks. In the first lines of this character the cars were carried upon two endless ropes, running parallel to each other, the same ropes serving to both support and move the loads, and were little more than a complication of the old Hodgson type of tramway.

In the system recently patented by A. H. DeCamp, and introduced as the "Acme" system, these functions are performed independently, as in the Bleichert system, the cars traversing a double line of flat steel bands, and motion being imparted to them by means of light endless traction rope, which travels centrally in respect to the track bands, and to which the cars are attached by patent grips. The track bands are laid "flatwise" in the supporting saddles, and are joined by clips of simple construction, over which the cars ride very easily. If the loads are very heavy these bands are doubled or trebled, one being placed above the other. Ropes may be used in place of the flat bands if preferred. The principles which govern the height and spacing of the supports are the same as in the Bleichert system. The terminal structures are simpler, since no overhead rails have to be provided for. The cars, after being detached from the traction rope,

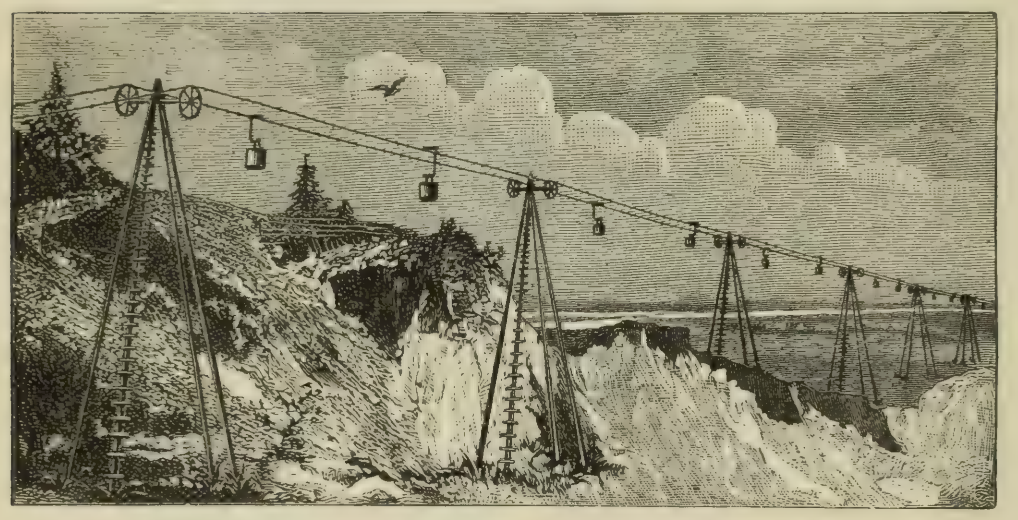


TERMINALS, WIRE-ROPE GRAVITY INCLINE.

which operation is automatically performed, are simply conducted to the ground on to surface tracks. For quarry-work this is very convenient; light portable tracks being used, which can be shifted as the face of the quarry is worked off. The cars are usually designed to dump from the bottom, which permits of an automatic discharge at any desired points along the line of the tramway, a feature well illustrated in the views of the Cedar Hill Lime Company's line at Port Kennedy, Pennsylvania, one showing how railroad-cars midway between the terminals are loaded, without arresting the motion of the car, and the other how the stone is similarly deposited at any of the kilns where needed. We also present a view of a line at Ivanhoe, Virginia, used by the Pennsylvania Zinc and Iron Company for transporting iron-ore from a branch of the Norfolk and Western railroad to their works on the opposite side of New river. In this line ropes of the patent interlocked pattern are used in place of the flat bands.

Where the ground for the greater part of the distance admits of surface tracks, but is rugged in places, with ravines and rivers to be crossed, a combination of surface tracks and "Acme" tramway may be employed to advantage, the latter being applied only to the bridging of the valleys, streams, and other points where it would be impracticable to lay surface tracks. By transporting the material thus in a continuous string of comparatively light loads (each car being provided with an independent grip), it is evident that a very large tonnage can be sent daily over a surface road of light rails, while the suspended way renders bridges and trestlework unnecessary, and the first cost of the roadway is therefore considerably reduced. The cost of operation, maintenance, and repairs in this system will compare favorably with that of any other mode of transportation.

Where there is considerable difference in the elevations of the terminal points, aërial inclines are constructed which operate in the same manner as an ordinary engine or gravity plane, the carrying cables simply performing the function of surface tracks. The traction rope in this case, instead of being endless, terminates with each of the two cars. If the load is an ascending one, the line is run by a motor of some kind, but if it descends, gravity becomes the motive power. A line of this character at Aalsund, Norway, has a clear span of 2250 feet. The angle of inclination is about 45° and loads of 1200 pounds are lowered at each trip, the descent occupying about 1½ minutes. One hundred tons of ore per day are transported in this way at a very low cost. Similar lines are used in Switzerland for lowering logs down the mountain-sides. In many lines of this character the moving rope is endless, and passes around a sheave at the lower terminal, which may be counterweighted or stationary according to circumstances, this construction being necessary in cases where the sag of the rope otherwise would cause it to drag on the ground or interfere with objects under the line. This arrangement also permits of operating from the lower terminal if desired, as exemplified in a line for conveying stores from the town of Gibraltar to the fortifications at the summit of the rock. This line is 2200 feet long, with a vertical rise of 1200 feet, and the two cars are designed each to carry a load of 1000 pounds. The motive power is supplied by an engine at the lower terminal, and the cars are run at a speed of 450 feet per minute. There are six intermediate supports, the last span stretching from the rock bluff to the town, being 1150 feet in the clear. A similar line is now being installed by La Gran Fundacion National Mexicana, near Santa Catania, Nuevo Leon, Mexico, for lowering ore down a steep hill, the buckets of which are self-dumping. The length of the line is 800 feet and the fall about 440 feet.



ARCHITECTURAL EDUCATION FOR AMERICA.

I.—THE ECOLE DES BEAUX-ARTS.

By Arthur Rotch.

IT would not seem extraordinary if a man about to build a house should say that he intended to consult an engineer as to the drainage of his site, and to employ a designer to plan for his requirements and to give him within and without an artistic building; that he should have the detailed specifications of materials, hardware, etc., written by an experienced builder and the materials themselves submitted to a practical chemist to test their durability; that construction-drawings should be made and carried out by a skillful engineer responsible for all settlements, shrinkage, or leakage; that the plumbing and heating should be devised and supervised by experts; that an artist should be engaged to watch and correct the models for carving and moldings and the execution of them; that the same or another genius must choose the shades of paint or stains to harmonize with whatever he, the owner, might select for papers or hangings; that he should expect to have always on the spot a competent overseer, and, though in view of the multifarious crafts and arts involved no one man might be competent in them all, he must have always on hand an expert, at whatever cost, in each department to pass on work and materials; also, that he must have an expert accountant to keep these many accounts balanced, so that at any time the owner could know what payments were falling due to contractors on certificates from the heads of departments. This accountant should also watch carefully the certificates for payments to detect errors by work omitted, or for allowances in the contract to be deducted, and should be competent to discuss these questions with contractors as a business manager might. If a man should say all this to his friends, they might retort that it would involve a very expensive staff, and ask, even if expense was not to be considered, who would be chief of staff and keep these departments and their heads coördinated? It is possible that it would then occur to the owner to supply an architect as chief of staff. Probably that would be satisfactory to all concerned.

Now, no doubt a man who should act as in this hypothetical case would have a better built, more comfortable, and more beautiful house than his neighbor, and yet, in spite of the immense sums lavished on buildings, this sort of expense is practically never incurred.

The qualification of all these experts is needed to carry a building to completion, and an architect is expected to fill all the gaps. Why should he do all these things? Because, from the nature of the temperament which called him to such a career, his pride will urge him to make his building the best he can make. The remuneration of an architect is so small, compared to his expenses, that he is forced to look to results satisfactory to his conscience and to gratified ambition as the chief results of his career. He will make a gallant fight to fill the places of all the needed experts above mentioned, and his enthusiasm will receive a rebuff as soon as he falls short of his impossible attempt. He will be blamed because he is not omnipresent or omniscient, but as he knows he has only himself to thank for undertaking the impossible he will not complain openly.

It has come, through the architect's own fault, to be considered his duty to place at his client's service all these many qualifications, each of which presupposes special training and the exercise of which in the aggregate requires a broad-minded, forceful personality and the tact born of knowledge of many things and many men.

If, then, we ask how one can best fit an architect for his career, there seems to be but one answer: the broader the foundation laid for it the better; the most liberal education is the best. It is obviously impossible for a young architect to know the multitudinous details which experience alone can teach. Every day and every year must bring its store of such knowledge. But there is another kind of knowledge which is not picked up in practice and whose absence experience only emphasizes. There are whole ranges of subjects which can be learned only from the professor or in the academic laboratory, and these studies which stimulate investigation and train the judgment are not to be found in the most extended practice. Chemistry and its kindred sciences, which decide the use of new materials, must be studied in the laboratory and lecture-room. Heating and ventilation and many other branches can be learned expeditiously only under a professor, and where so many subjects must be studied the short road to learning is the best for the architect. It seems, therefore, that at least a certain degree of academic training is needed to round out an architect's education, even supposing that he can learn the esthetics of planning and designing in office-work.

As an architect's practice ever offers to him the solution of new problems, and as he is tempted constantly to copy blindly the fashion of the day, it is of the utmost importance that he should face his bewildering conditions with sound principles of design and construction.

The young architect requires a pure esthetic code to guide him when bewildered by specious influences. Like all moral influences such esthetic principles must be absorbed slowly and in a propitious atmosphere. Traditions for a time must submerge personality. Traditions which are the fetters and limitations of an old civilization are stimulating guides in the new.

Feeling the need of such traditions, Americans have been most attracted by the École des Beaux-Arts at Paris. It is magnificently endowed, with every facility for and every incentive to study all branches of art. Its splendid library is freely open to students. Lectures in history, esthetics, mathematics, and the constructive sciences are given by eminent specialists. Frequent *concours* offer distinction in many branches. Founded in the middle of the seventeenth century, its early teaching was a timid classicism whose chief merit was the close study of the old Roman plans,—the most splendid the world has seen. Still keeping the latter in view during this century, and especially in the latter half of it, the School designs have gained greatly in vigor and richness. An influence of value came from Viollet-le-Duc's attempt, a generation ago, to substitute for Classic models Gothic designs in the school ateliers. The revolution did not succeed, but the great medieval archæologist's protests against the sham construction of the Roman Classic style and his exposition of the beauty of truth in constructive design have emphasized the value of rational architecture.

However artists may differ as to styles, the principles of largely-conceived symmetrical plans are immutable, and the École des Beaux-Arts student in this has no rival elsewhere. In general it may be said of the school that its influence always makes for a large symmetrical treatment of masses and a subordination of details in the composition.

The training of the École des Beaux-Arts is such that the students in architecture, as well as those in painting and sculpture, graduate with definite principles to guide their subsequent work. The students under this liberal instruction on returning to America rarely reproduce French types of architecture, but, applying the principles of design they have imbibed, seek to express the functions of the building by a logical use of the materials available.

This is the mental attitude our architects should have. They are confronted with novel problems and new exigencies. These can only be met successfully by cultivated training which leaves no *parti pris* in style. The well-stored mind must be alert to seize new points of view; then, guided by sound principles, it will produce rational architecture, *i. e.*, buildings whose purposes impose their plans while the available materials decide their exterior treatment.

There is another advantage which belongs peculiarly to this institution, and that is the all-pervading artistic influence in which its students are steeped. The close connection of the students in architecture, painting, and sculpture, their great numbers, their distinguished professors in active career, the ardent competition and penetrating sense of the value of hard work, all create an incomparable atmosphere for artistic culture.

It is distinctly to the Beaux-Arts at Paris and its direct influence through pupils, or indirectly through the schools in America which have followed its lead, that the splendid buildings in its own chosen style at the World's Fair were erected.

In conclusion it may occur to the reader, as it has to the writer, that there is a curiously familiar sound to the above considerations—a haunting sense of having heard the drift of it before. And so we have. It is now nearly a generation since the discussion as to college education waxed high. The American people have long since settled that. We rarely hear now the old-time tirades against the waste of time for business-men to go to college. Americans want to be something more than subordinates, and they know that the most liberal education leads to the front.

II.—A PRACTICAL TRAINING.

By Robert D. Andrews.

THE young American who intends practising architecture has two recognized resources for his education: the architectural school and the practising architect's office. These, between them, with a little foreign travel, are supposed to supply all that is necessary student to know before he begins practice for himself.

Our schools are modeled upon the schools of Europe, where for the most part design is taught in its theoretical sense. Their general air is one of conservatism. Past achievement is not scrutinized in the light of modern thought and tested by modern standards, but certain types of development are conventionally accepted as representing the best the past has to offer us, and the *summum bonum* of modern design is to secure the closest possible approximation to these conventional types. The objection to the ordinary school is not so much on the ground of what it teaches as of what it leaves untaught. Design on paper can at best be only theoretical. The demonstration of its practical fitness or unfitness is unattainable. Hence it is not surprising to find the schools which have no equipment for the practical demonstration of the relative fitness or unfitness of design centering their attention upon such virtues as may be displayed on paper. Our criticism of them must be the broad one that they lack such equipment.

That theoretical design which the schools teach, our unfortunate conditions of practice tend to enforce. The established system of paying all architects alike, on a commission basis, makes it necessary for an architect, if he would prosper financially, to secure a large amount of work. The money premium is set on quantity, not quality. As a result the architect becomes primarily an organizer, a hirer of draughtsmen, a man of affairs. The work of his office becomes specialized. The designer designs, the constructor constructs, the superintendent superintends, and the architect busies himself with administration and his clients. The superintendent is the only person who is brought into close and constant contact with the actual work, and he is the one person who is considered least worthy to design.

We find that in the office, as well as in the school, the student, or draughtsman, whose education we are following, has no systematic means for coming in touch with the actual materials for which he is obliged to design. He is rarely permitted to follow the execution of the work he has drawn, and frequently never sees it. As he receives his most important inspirations by paper, through the medium of books and photographs, so he is obliged to express himself by paper. Thus in office and in school, alike, the student is shut out from the influence of the realities of the art he is supposed to be acquiring.

Now, as a matter of fact, it is acquaintance with just these realities of building that the modern student misses, which has created the very art of design he is aiming at. In the centuries immediately preceding the crowning achievements of both Greek and Gothic architecture, the architect, as we know him,—a person forcing designs upon all sorts of craftsmen,—was undreamed of. Every craftsman made his own designs because, forsooth, there was no one to do it for him. Art, as such, was ignored, and the carpenter and mason and smith worked in all simplicity of mind at their respective tasks. Therein lay the charm of their work, and the secret of their ultimate growth and power. For in their close and undisturbed relation the material spoke with its worker, and told its secrets to him. It taught him its utmost resources, and its limitations; it lent its grace to crown his work, its strength to fortify his reputation as a craftsman, so that his heart went out into it, and he loved it in all unconsciousness and sought to display it ever more and more advantageously. Thus grew these two great races of Europe to the flower of artistic achievement, simply by working out, without any preconceptions, the familiar demands of their own local conditions. No foreign traditions dominated them, no school restrained them, and humble artisans were the means employed to dower the world with yet unrivalled beauty.

The architectures of Greece and of thirteenth-century France are the fountain-heads of our noblest inspiration because they spring from the soil. They express the heart of humanity. But after they had revealed their unexpected splendor and won the popular attention, men began to consciously seek to secure for their own times the beauty that was in the earlier work. Art woke to self-consciousness, and first learned to seek her own ends. Her high priests, the patron and the architect, arose and taught the craftsman how he should design. And in proportion as the architect gathered the rights of design one by one into his hands, and left the craftsman's task an unimaginative and purely mechanical one, the better men deserted the crafts, until only the broken-spirited and dull remained. More and more the architect was compelled to rely upon those qualities of art that may be consciously effected, formal symmetry, grandiose scale, complex and ingenious disposition of detail and mass. The old, fine, human sentiment of the work perished, and art became a matter of the intellect, often powerful and impressive, as a cliff or the ocean is, if only by reason of size, but no longer lovely in every part.

If we recall the architecture of the United States about the year 1850, we can form a just estimate of the depths of degradation to which this separation of design and execution has led. The recent revival of architecture here is due to the stimulating effect produced upon our architects by the contact with the vital work of Europe made possible by photography and ready modes of travel. The beneficial effect of this stimulus is already waning, as we may see by the increasing introduction of the meretricious features of Roman design.

We have the question squarely to meet, whether we shall drift along and repeat the experience of ancient Rome, borrowing our architecture from our betters, and using it as a cloak for luxury and mental idleness; or whether we shall make a stand for an honest, self-respecting, and progressive art. It seems to me a very critical time, and upon the action of the present generation the hope of American architecture may depend.

I have tried to express, as forcibly as the brief limits of this paper permit, the weak side of our architectural education, and the especial nature of its weakness. My suggestions for arriving at a better state of things are these:

First, to bring the architect (and the student with him) closer to his work, I would like to see the client demanding a certain specified amount of his time at the building, and paying him a specially agreed upon sum for his services instead of the usual commission. I believe the architect could save to the owner under such conditions a sum nearly equal to his present fee. The architect's office for that work should be immediately adjoining the building, as a contractor's is.

The advantage to the draughtsman in being always at the work is apparent.

Second, to improve the school training, I would join to each school a school of building trades. I can imagine these two schools on either side of an important central court, with museum, library, hall, dining-room, and gymnasium in common. One head would insure harmony of coöperation. The main object in view would be to familiarize each class of students with the other's point of view ; and the familiar intercourse between the two schools, with the mutual understanding and comprehension resulting, would constitute an important factor in the results expected.

I would revise the present disconnected modes of study, especially in elementary courses, so that the occupation of one hour would form a proper sequence to that succeeding, bringing the teacher's convenience to suit the pupil's, rather than otherwise. I would establish the lines of study more or less on structural rather than historical development, considering organic relations of highest importance. Beginning with the nature and capacities of common materials, constantly illustrated by reference to their historical employment, I would lead the student on to the construction of the familiar parts of building in their natural order, arriving at the most abstract and subtle creations of art at the end. Meanwhile, problems in the use of materials and practical design would be carried out in the courtyard. This courtyard I imagine to be a veritable museum of current art. The architect designs, the craftsman executes, while the library and museum furnish their silent comment. The craftsman, too, should match his design against the architect's, the courtyard constituting a free parliament. The architect might leave the school as a craftsman, or the craftsman as architect. The conception of the school is not to produce fine craftsmanship or fine design, but to gain good architecture ; to make both architect and craftsman feel that the other is essential to his success ; to establish that bond of intellectual sympathy without which the best of intentions are useless.

Thus may we begin that reconciliation of execution and design, of architect and craftsman, whose present wide separation is a reproach to our intelligence, and the worst menace to our art.

EARLY ARCHITECTURE AND ENGINEERING IN PERU.

By Mme. Alice D. Le Plongeon.

EVER since the Europeans have known America the attention of the fortune-hunter and the antiquary has been attracted particularly to Peru. It was the treasure-house of the Spaniards in the days of their undisputed control, while for the scholar it has been, and is, a rich field of research. From the coasts to the dizzy heights of the Andes vestiges remain of the handiwork of a prehistoric race, while the soil is white with the bleached and powdered bones of millions of human creatures. For Peru, up to the time of the Spanish conquest, was densely populated, although the people rapidly diminished in numbers under the harsh treatment of the invaders. Many thousands perished in the mines, and these were only one portion of the hapless victims of the Christians. The Inca civilization, which many suppose to have been the principal and dominant power in ancient Peru, was but one incident in the history of that country.

The first Inca, Manco Capac, made himself a king about A. D. 1020 or 1021. Atahualpa, the last Inca who actually ruled over his people, was put to death by order of Pizarro in May, 1532. Thus the whole Inca reign endured for only a little more than five hundred years, and was, comparatively speaking, an event of modern times. Certain native records go to show that Manco Capac was descended from a line of Peruvian kings. But all the country now called Peru was not in former times occupied by one nation. On the coast were the Yungas and the Chinchas (also called Changos), who were conquered by the Incas after a stubborn resistance. Older people than those of the Inca period were the Aymaras, who in turn were preceded by the Collahuas. Up in the region of Lake Titicaca vestiges are found of the handiwork of yet another people, older and more civilized. The ancient city of Tiahuanuco, now reduced to scattered stones, bears witness to this.

As a result of its varied population the investigator finds in Peru more than one style of early architecture. The variety of materials employed afforded a reason for this, more powerful than mere fancy. It was a matter of convenience, the builders utilizing those materials nearest at hand and best suited to the climatic condition of the various localities. Thus, the cities on the coast, where no rain falls, were built of sun-dried bricks—adobes—not only by the early people of those parts, but by the Incas themselves after they acquired supremacy. The material most suitable for that climate was already on the spot. Further inland, in the valleys, where stone abounds, it was used exclusively, roughly piled up as shown in an accompanying illustration, made from a photograph of a gateway at Calaveras. Up in the mountains the Inca buildings were made altogether of stone, as were those also at Tiahuanuco, where we may see the most marvelous stone-cutting to be found in any part of the world. This work, the natives say, was done so long ago that it was before the sun shone in heaven,—their poetic way of saying that the history of the place is lost in the night of time. Pinelo, the well-known Spanish writer, compared the walls of Tiahuanuco with those of Assyria. Montesinos claimed hundreds of centuries for some of the Peruvian structures, but his work is not credited.* In his work, "Sacred Mysteries," Dr. Augustus Le Plongeon has explained that Tiahuanuco was probably the work of Mayas, and may therefore be coeval with the early civilization of Egypt and Assyria.

There is no way of ascertaining exactly the age of the cities on the coast. If called upon to give an opinion, we should say that they are between fifteen hundred and two thousand years old. But they must have been built on the ruins of still older cities, if we may judge from the vast number of burial-places and from the images of wood and stone found forty to sixty feet below guano-deposits, which deposits have been estimated to increase only between one and three inches in a century. It has been suggested that these remains belong to the period of "the mound-builders," but we have no means of verifying this.

The whole country is covered with vestiges of towns and villages. Beginning with the architecture of those on the coast, it is evident that size and solidity were the chief aim of the builders. The city of Chimu Canchu, not far from Trujillo, seems to have been three or four miles square. There are vestiges of a great causeway, forts, palaces, and burial-places that have been rifled of their precious contents.

Generally speaking, the houses were quadrangular, but some were round or polygonal, to suit the space in which they were erected. The walls were remarkably thick,—as much as ten, fifteen, or even twenty feet at the base, in the larger edifices. In smaller ones, poor dwelling-places, they were four or five feet thick, and sometimes only one foot. The walls were sloped on both sides, decreasing in thickness all the way to the top, so that a wall twenty feet thick at the base would terminate in a thickness of only three or four feet. This insured extreme solidity, and the method was perhaps resorted to in consequence of the violent earthquakes so frequent in that part of the world. The majority of the buildings were fifteen to twenty feet high, generally with no second floor. In Chimu Canchu, Sacsahuaman, and some other cities there were houses of two and three stories, their total height being fifty or sixty feet.

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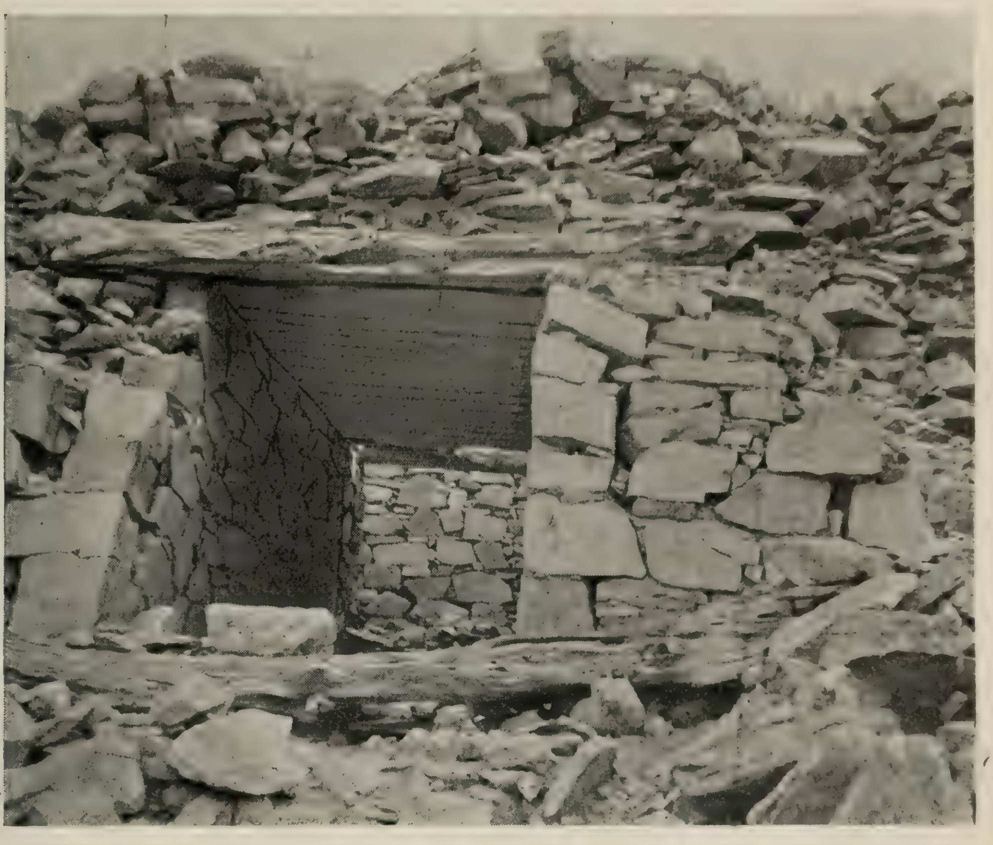
*Prescott, Vol. II.

The adobes used in building were of two kinds. In the course of time these bricks have become so hard that it is difficult to break them, even with steel instruments. This is also the case with the elaborate ornamental stucco-work, of which an illustration is given, showing the interior of a large room in a three-story building. One kind of adobe used was cast in molds. An interesting fact is that measurement has proved such bricks, in many different localities, to have been of the same size,—namely, eighteen inches long, nine inches wide, and five inches thick. Clay mixed with gravel and chopped grass were the materials used in making them. After having been sufficiently dried in the sun, they were laid, in the building of walls, just as the modern bricklayer does his work. Clay was used to make them adhere. To-day, in Peru, adobe walls are built in the same way, mortar being used only with burned bricks.

Other adobes, found very largely in the old city of Pachacamac, and evidently of greater age than those above described, were not cast in molds. They are irregular, unshapely, rounded, apparently like a mass of moistened clay, rolled and pressed between the hands, and left to dry without further finish. Finger-marks are visible on the surfaces. These adobes are found principally in sepulchral mounds and houses of the poorer people. The adobes most commonly employed on the western slope of the cordilleras in all kinds of edifices are called *paredones*. Their shape is cubic and rectangular, being six to eight feet long and three or four feet thick.

Walls entirely of mud were built then, as they are yet in that country. A form was made with boards held together by ties so arranged as to be easily removed. The form was similar to that used in building concrete walls. In it the workmen placed a quantity of moistened earth, which they treaded or pounded with a wooden or stone pestle or stamper until the mass was solid. They then added more earth and repeated the stamping process until the form was filled, when the boards were taken apart. Such walls became hard enough to resist the elements and the earthquakes.

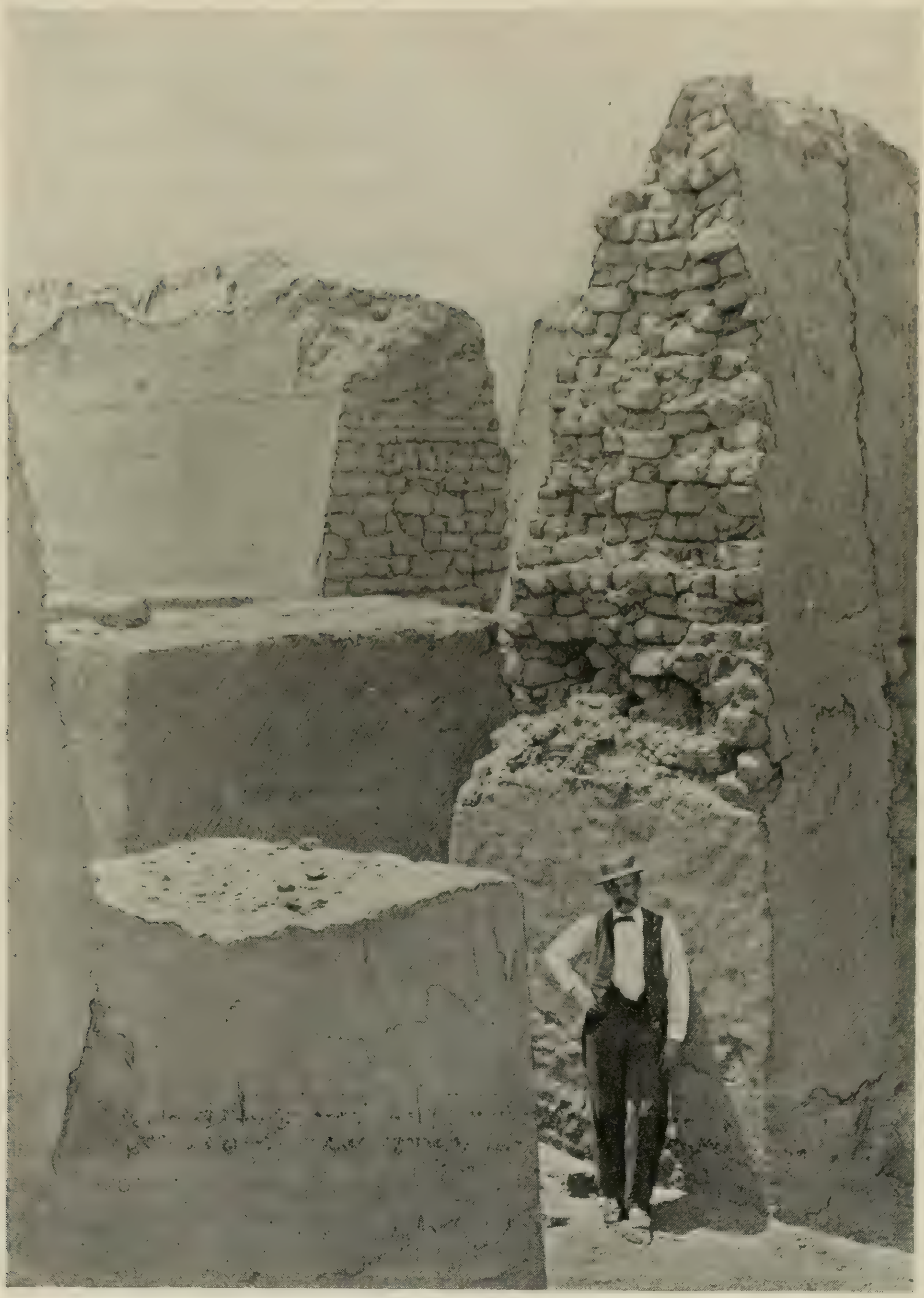
At Chimu Canchu, among the great number of buildings of which remains exist, one is in a state of preservation that enables us to obtain a correct idea of the general method of construction. It is believed that the building may have been a prison ; it contained forty-five rooms or cells, each isolated, and having no entrance except through a square hole in the roof. The walls and the roof, which is four feet thick, appear to consist of a sort of hard concrete, formed of clay and pebbles. Walls and ceiling were clay-plastered and smoothly finished. The roof was so solid that Dr. Le Plongeon and two other persons rode over it in perfect safety, although there was no trace of any wooden or stone beam anywhere. Careful examination led to the belief that when the walls were of the desired height a flooring of bamboo canes was laid over the building. On that strong and resistant surface the concrete mass was applied, and when it had hardened the canes were removed from beneath.



REMAINS OF A GATEWAY AT CALAVERAS.

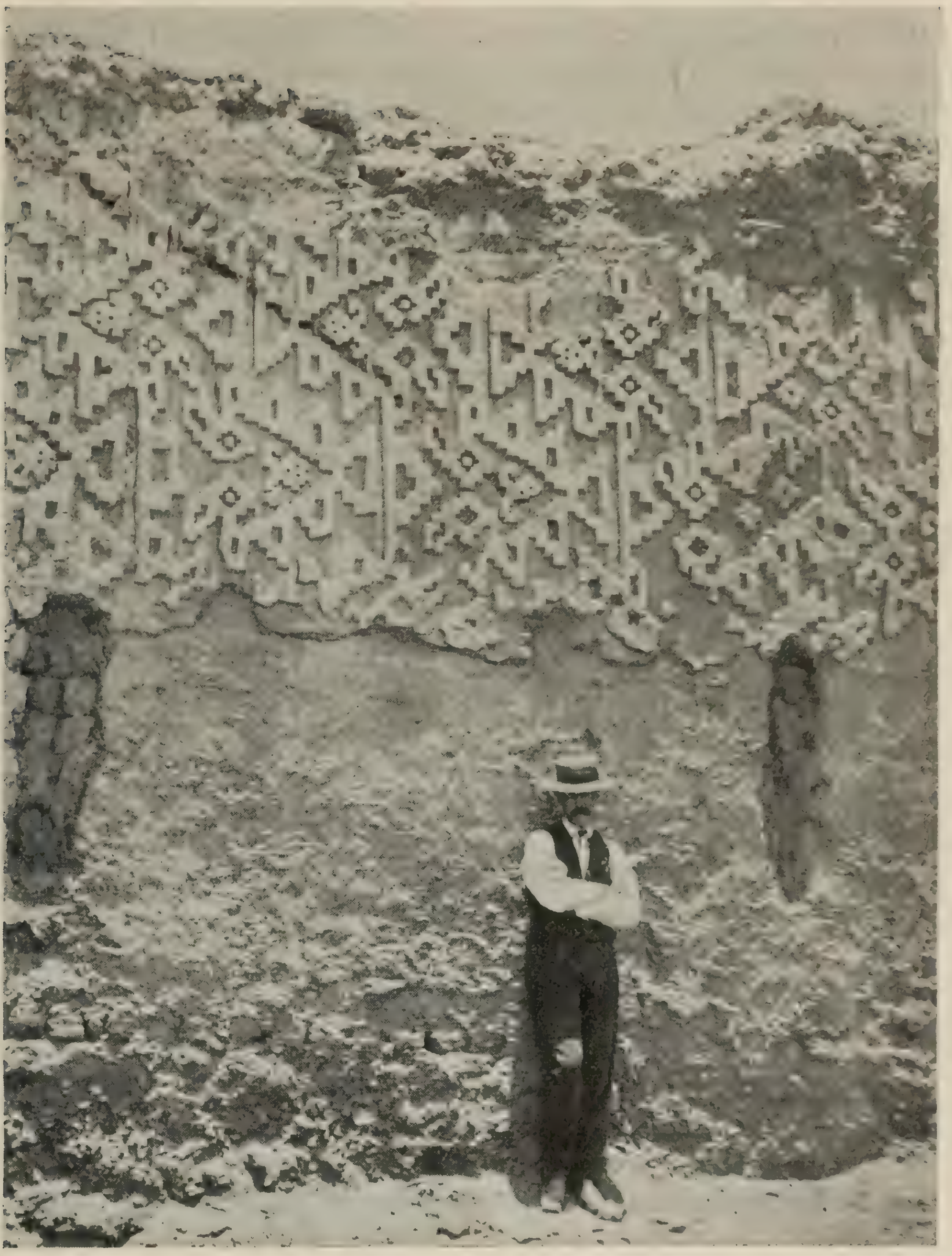
Leaving the coast and ascending the cordilleras, where rain falls copiously, no more adobes are found. All the structures are of stone, —a material found on the spot and best suited to withstand the torrents of rain. In some constructions, particularly those of little pretension, the stones were cemented with clay. But in the houses and fortifications of the eastern slope the stones were hewn and adjusted with such precision that it is not always easy to determine their line of junction.

The Peruvian stone-cutters had tools of copper, tempered with tin.



ANCIENT ADOBE WALLS AT CHIMU CANCHU.

These are frequently found in graves, but when tried on hard stone they soon become blunt and useless. It would seem, therefore, that the workmen must have had other means to enable them to accomplish their remarkable stone-cutting, including the fine carvings in emeralds, jasper, granite, and porphyry. Among the uneducated classes of Peru



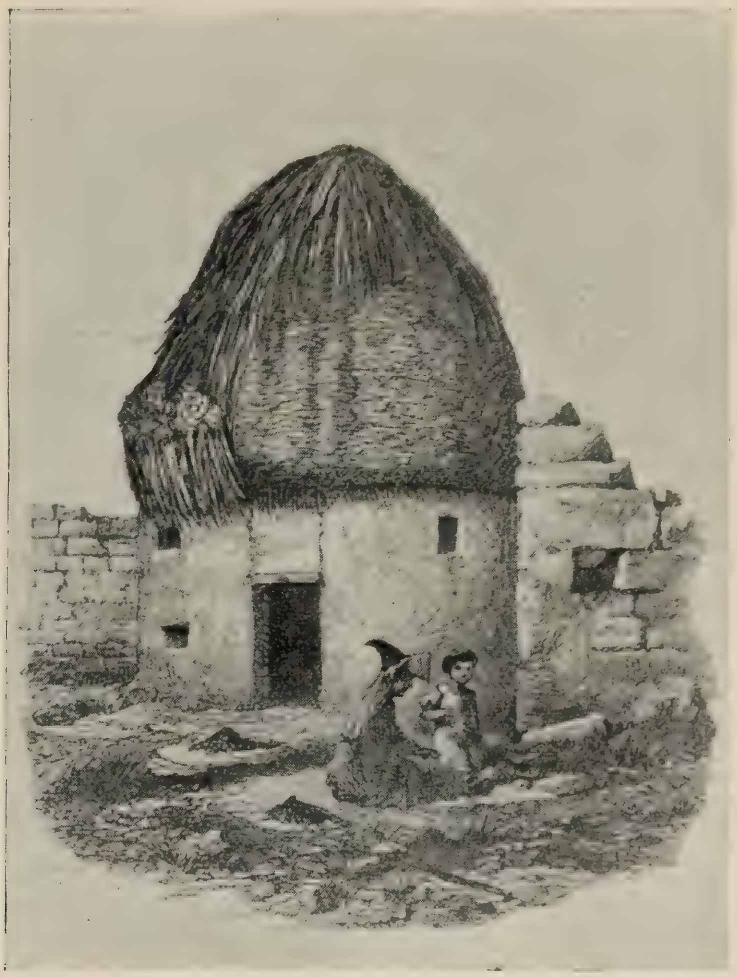
ANCIENT STUCCO WORK AT CHIMU CANCHU.

the idea exists that the ancients possessed the secret of softening stone by means of vegetable juices. The fact is that they succeeded, apparently without steel or iron, in doing with admirable perfection whatever they pleased with the hardest stone. Some writers have asserted that cement was used between the stones, but we have failed to find traces of anything of the sort.

As Humboldt says, "simplicity, symmetry, and solidity are the three characteristics that advantageously distinguish all the Peruvian edifices." The homes of the people were extremely simple. The rooms were few and had no communication with each other, each being provided with but one door, opening upon a courtyard or the street. There was no window or other aperture. The doorways did not exceed four feet in height and two in width, while in form they usually resembled those of Egyptian temples, being narrower at the lintel than at the threshold. The builders had most fantastic notions regarding doorways, for they made some narrower at the bottom than at the top, while others were shaped like jars of various forms. In the interior walls niches were made to serve as closets for domestic utensils. Beneath some floors there were cisterns shaped like conical jars, which served to store grain and other comestibles. The walls of the cisterns were smooth and hard ; they had notches in which to set the feet in descending to the bottom of the granary, generally fifteen feet below the surface. The entrance was covered with a stone slab. Under the walls of some houses subterranean recesses have been found —the family ossuaries—filled with human bones.

GATEWAY OF INCA FORTRESS AT PLLANTAYTAMBO.

The palaces of the Incas and homes of the nobles were large and commodious, yet remarkably simple in their exterior construction, having no columns, cornices, or other ornamentation. Interiorly they were divided into large apartments and small chambers. The large rooms communicated one with another by intermediate doors and also, like the smaller ones, opened on a yard or a corridor that surrounded the building. Numerous windows afforded light and ventilation to the large apartments. The walls were elaborately finished in polished marble and other stone, in some cases beautifully carved and decorated with ornaments of precious metal. Niches finished with fancy moldings were made to contain gold and silver figures of men and animals. In humbler dwellings the floor was merely leveled and stamped earth, but fine residences had marble floors of various colors, sometimes with thin plates of gold between the slabs. The doors of large houses generally faced toward the east, were lofty and wide, and usually shaped like those of Egyptian temples.*



INCA ROOF OF MOUNTAIN GRASS.

[The only specimen of this roofing now extant. Illustration from Markham's work.]

The lintels of Inca doorways were heavy timbers roughly squared, or large slabs. Doorways were never arched, though the Peruvians knew how to construct an arch, as vestiges existing in several places show; while in the valley leading from Pachacamac to the Sierra there are small houses with domed roofs made of adobes, the semisphere being perfect. A distinctive feature of the Inca architecture was that the roof was always of a different material from the walls, being made of wood, straw, canes, or rushes. *Ichu*, or mountain grass, was most generally used. The only Inca roof remaining in a perfect state has a total thickness of five feet. The outer layer, two feet thick, was of grass, laid vertically with such regularity as to present a perfectly-smooth surface to the weather. Next came a thick layer placed horizontally and matted together with reeds. The third and inner layer was placed vertically. The structure supporting this roof is called *sondor huasi*.

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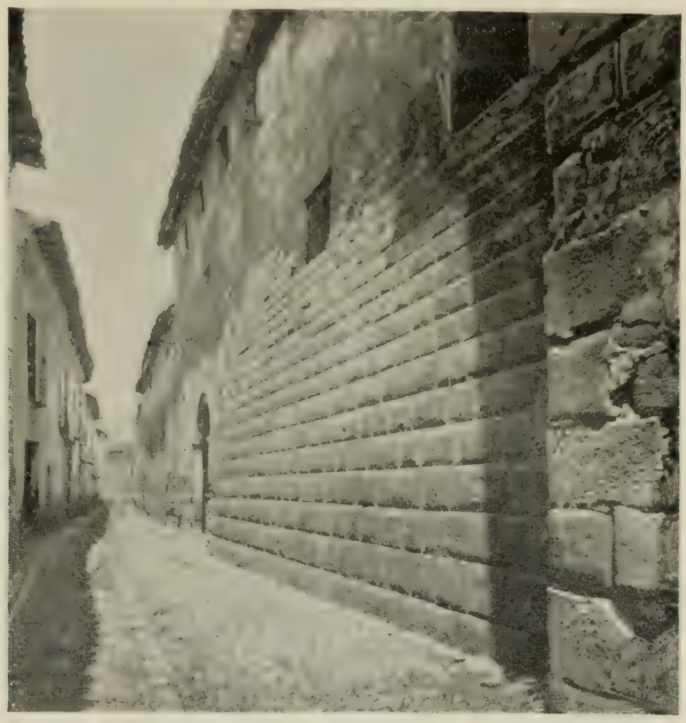
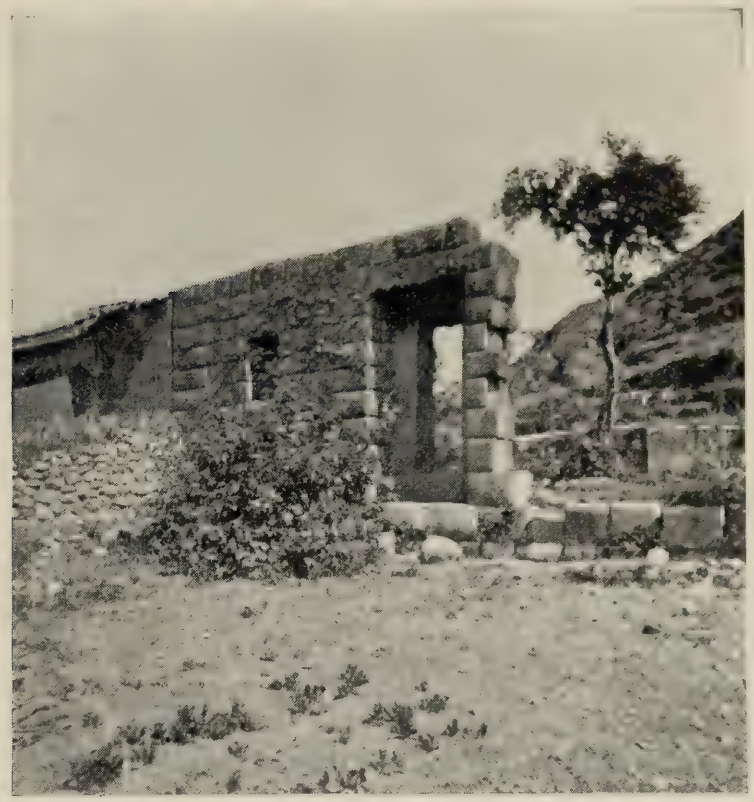
*Modern researches are leading to the belief that the points of resemblance between Egyptian and Peruvian architecture were due to the fact that the builders of the two were kindred peoples. Dr. Le Plongeon is proposing to show, in a forthcoming book, that in remote times the Mayas—whose empire extended from the isthmus of Tehuantepec to that of Darien—were a colonizing and civilizing people, just as the English are to-day, who carried all over the earth their civilization, their sciences, arts, and traditions, which are found to have reached all the civilized nations of antiquity. They reached both Peru and Egypt. A. D. L.



WALL OF INCA PALACE AT CUZCO.
[With Spanish-arched Doorway.]

In the cities, houses adjoined each other, being built in continuous rows, forming long narrow streets which intersected at right angles. The outer walls were painted red, the general effect being somber and monotonous. The Inca buildings were remarkably spacious, their public edifices accommodating several thousand persons. The palace of Huayna Capac, the twelfth Inca, was eight hundred feet long. Incarial structures in general were square, oblong, and cyclopean, of granite, porphyry, and other stone, laid in symmetrical and accurate courses. The walls, like those of adobes on the coast, were very thick at the base, decreasing gradually toward the top. Dr. Le Plongeon discovered that the large stones had been got into place by the united muscular strength of many men, working upon a series of inclined planes, with the aid of levers and wooden rollers.*

It is not possible to say what populations these ancient cities had, for the reason that, although the Incas kept a very correct census of their subjects, the Spaniards destroyed those records (*quipus*). The city of Cuzco was not much more than a mile square, and its population is said to have been about sixty thousand.



AN INCA PORTAL AT CUZCO.

[A vestige of Manco Capac's Palace.]

On the southeast shore of Lake Titicaca, now Bolivian territory, once existed the city of Tiahuanuco. Not a building—nothing but one gateway—now remains standing, but the scattered stones excite profound admiration. Some are twenty-five feet broad, fourteen feet long, and 6½ feet thick ; others are forty feet long. Here, in their eager search for gold, the Spaniards destroyed remarkable walls, blowing them up with gunpowder. The stones were as finely finished as a cabinet maker might wish to see his wood. They were cut with alternate grooves and projections, like mortise and tenon, so as to fit into each other horizontally. Vertically they were held in position by round holes drilled in the top and bottom of each stone at exactly corresponding distances. It is supposed that short cylinders of bronze were placed in these. The stones were also held together with bronze clamps, of which vestiges have been found. The sides of the only remaining gateway at Tiahuanuco are absolutely perpendicular, like some of the Inca portals at Cuzco.

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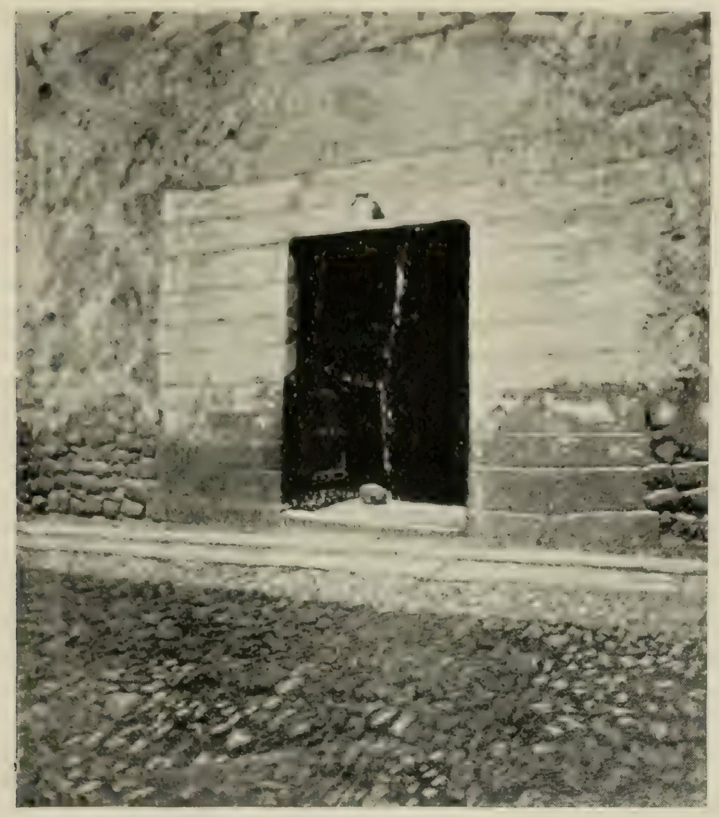
* This conclusion, reached from an independent standpoint, is of interest as being in harmony with Mr. Durfee's accounts of ancient methods of moving heavy masses, in recent numbers of the Magazine.—THE EDITOR.



AN INCA PORTAL AT CUZCO.

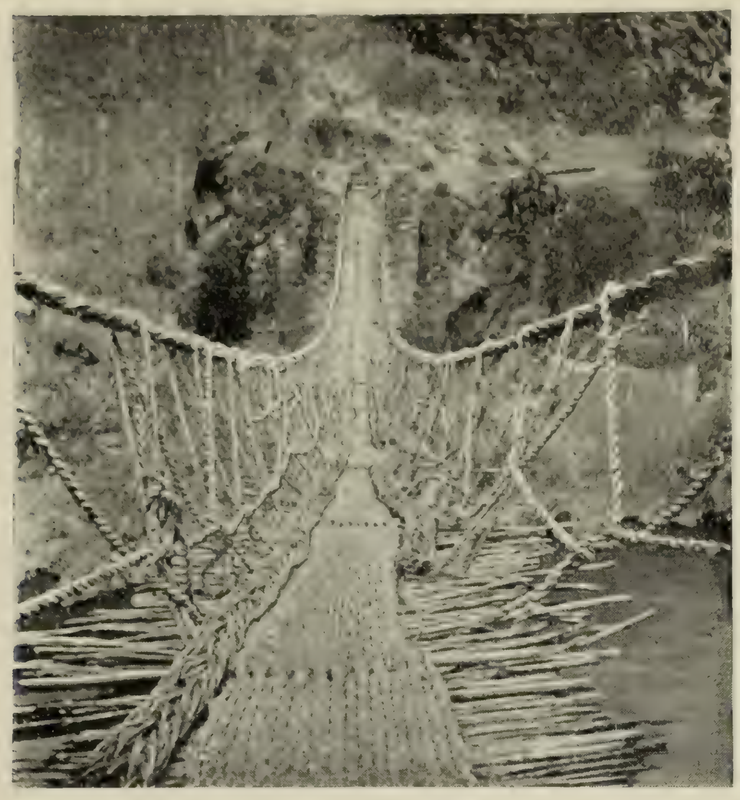
The Incas had a very complete system of fortifications. A notable fortress was that at Sacsahuaman, near Cuzco. It was finished only a few years before the arrival of the Spaniards, by whom it was stupidly destroyed. The outer wall of the structure was eighteen hundred feet long, composed of massive blocks of blue limestone, put together in cyclopean style. Some measured twenty-seven by fourteen by twelve feet. The largest in the fortress has a weight computed at 361 tons. That fortress was connected with the palace at Cuzco by subterranean passages ingeniously constructed, four feet wide and six feet high, but at certain places so contracted as to allow only one man to pass, stooping between sharp-pointed stones that lined the passage. A few persons could have held such a spot against many invaders.

The Spaniards marvelled at the highways which they found in Peru. Whether these were the work of the Incas, as is commonly claimed, or of a much older people and only kept in repair by those wise potentates, is a question not easily decided. By means of galleries and tunnels many miles in length, cut through the living rock, the pedestrian passed high mountains, pathless, and buried beneath eternal snows. Dizzy heights were scaled by stairways hewn in the rocky mountains. The Spanish historian Gomara says that the two principal roads were each a thousand miles long. One that crossed the plain was twenty feet broad, walled on both sides, and had ditches on the outside, the whole way being shaded with cubeb-trees. The road over the mountain was twenty-five feet wide, cut in places through the solid rock, and in others made of stone and lime. These roads were level and went in a direct line, not deviating for mountain or lake. After the advent of the Spaniards no attempt was made to keep them in repair, although Pizarro said "nothing in Christendom equals the magnificence of these roads."

Hideous chasms were filled with solid masonry. Some roads were paved with flagstones, others with pebbles and a glutinous composition that made them resemble our macadamized ways, but perfectly smooth and almost as hard as marble. Pillars, like milestones, were placed at certain intervals, a little more than three miles apart. Bottomless abysses, rapid torrents, swift-running rivers, were crossed by suspension bridges constructed of ropes made of agave filament. Bridges of wood or stone were thrown across small streams, but great rivers had rope bridges. The simplest form was a single rope over which the voyager was conveyed in a basket. The natives yet make use of that method, which is common in Japan also. Across the river Pampas, in Peru, there is a rope bridge 135 feet long. That over the Apurimac, one of

PART OF FORTRESS AT SACSAHUAMAN.

the head waters of the Amazon, is 148 feet long, its lowest part being 118 feet from the water.



ROPE BRIDGE, RIO PAMPAS, PERU.

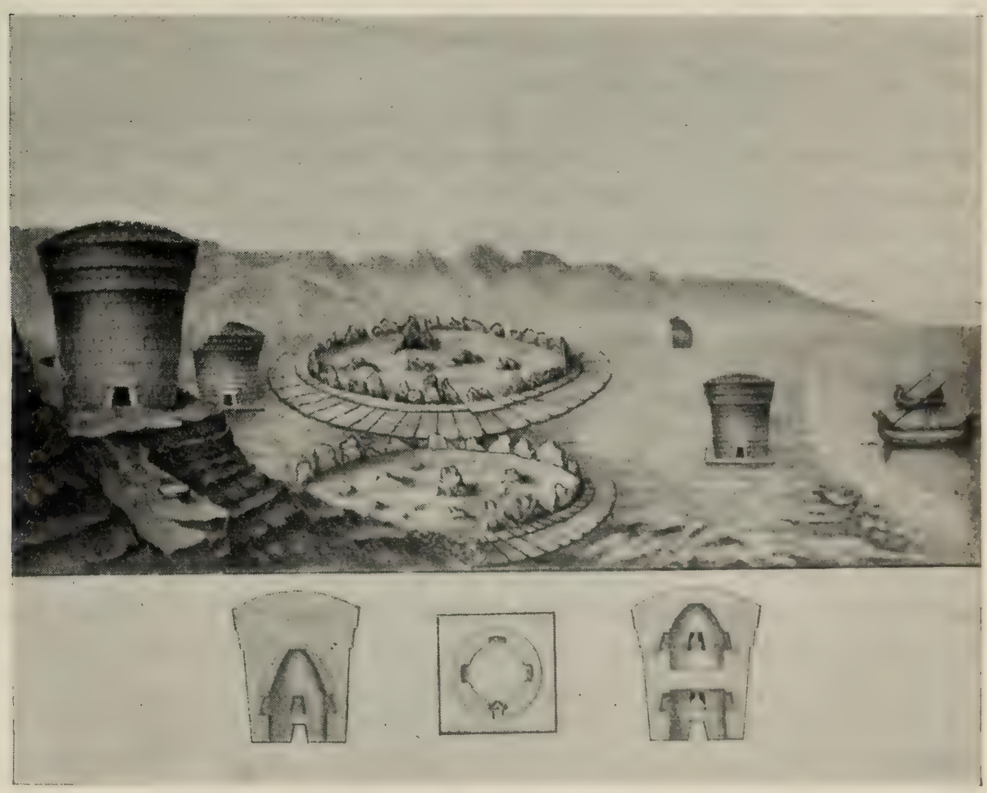
The Peruvian waterworks, whether constructed by the Incas or only kept in repair by them, are worthy of our notice. The Incas seem to have understood the law of fluids—known as equilibrium—their temples and palaces having been supplied through inverted siphons. Their system of irrigation was so complete that much of the now arid land was productive during the Inca period. The Spaniards destroyed part of the waterworks to possess themselves of silver pipes, and the rest have nearly all been suffered to fall to ruin. Stone canals, completely incased, were laid in the mountains, bringing streams of pure water to the cities. On the summit of the cordillera Dr. Le Plongeon followed the bed of one canal for a distance of fifteen miles on the slope of the Andes. Some of the canals yet exist; the valley of Nasca is watered by them and is surprisingly fertile.

In the mountains are many thermal springs and near by them are found the remains of buildings. The fountain-beds were paved and sheltered beneath concrete domes, which were surmounted by figures of animals from whose mouths the water spouted, falling into gold basins through pipes of the same metal, thence into porphyry reservoirs.

Not less interesting than the deserted homes of the living are the resting-places of the dead, in many cases containing valuable articles of gold and silver and always some interesting objects that had belonged to those whose bodies were there entombed. All the great mounds on the coast are burial-places,—tombs piled one above another, in order that the dead should cover as little ground as possible, leaving the soil for the maintenance of the living. The sacred city of Pachacamac (the Creator), a few leagues south of Lima, was a place of pilgrimage, and consequently the last resting-place of many thousands of human beings. The desert sands have covered half the city; that portion remaining has a boundary of four or five miles. The city wall, looming here and there above the sand, shows that it once inclosed a surface two or three miles square. The sepulchers of the Aymaras were truncated pyramids, twenty to thirty feet high. They placed their dead squatting in a circle. The mounds of the Changos were but eight feet high, interiorly. In these the bodies were laid straight out. The Quichua mounds were ellipsoidal and scarcely four feet high. The bodies placed within were seated with knees drawn up to the chin.

At Chimu Canchu, on the coast, some of the royal *huacas* or tombs were very extensive, consisting of several spacious rooms. Immense treasures were stored away with the dead kings; some of them have been found, while a continual search is being made for others.

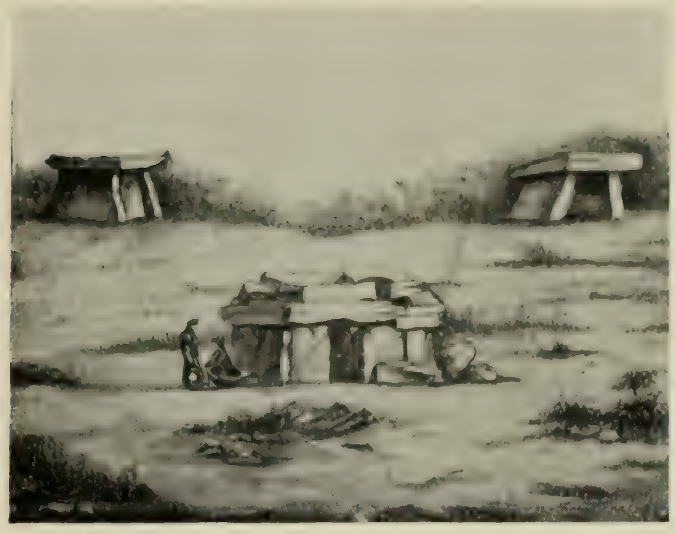
Except in unavoidable cases the Peruvians, owing to their enormous population, never deposited human remains in places that could be cultivated for agricultural purposes. They selected arid and



SUN-CIRCLES AND CHULPAS, WITH PLANS.

[From Sallustini, Lake Titicaca, Bolivia.]

sandy spots. Up in the cordilleras rock tombs are very numerous, and on the eastern slopes, from the brow of the mountains to the shores of Lake Titicaca, the tombs were of stone, the majority having the outward appearance of a mere square heap of unhewn stones. Some, called *chulpas*, near the shores of the lake, are circular towers, from ten to thirty feet high, their diameter increasing in proportion to their elevation. The stones forming the walls are cemented with tenacious clay. Their outer surface is curved to follow the line of the structure. The walls diverge toward the top, so that the diameter of the monument is greater there than at the base, presenting, with its domed roof, a very pleasing appearance.



KIT-KOTI. [From England.] PERUVIAN TOMB. [From Lake Titicaca.] TOMB. [From India.]

In some of these towers the interior is formed of upright stones on which rest broad flat slabs, serving as floor to an upper chamber, whose ceiling is always a perfect vault. Others had no upper chamber. Niches were made in the interior face of the wall, corresponding to the four cardinal points, and the bodies were placed therein. These chulpas have a small doorway through which one person can enter on all fours. Another form of stone sepulcher is the primitive structure which strikingly resembles the *kit-koti* found in the British islands; similar monuments exist in many parts of the earth. Our illustration shows one of Peru, one of India, and one of England.

The only other Peruvian structure to be mentioned is the sun-circle, called in the Quichua tongue *inti-huatana*,—"the place where the sun is tied up,"—a name which would indicate that the circle was intended as a representation of the horizon. These circles are found in many other parts of the world, as at Stonehenge, in England, and at Darab, in India. Concerning their origin and purpose there has been much speculation, but only in Peru has the name given to it been such as to indicate the object of the structure. Sun-worship existed in Peru, we are told, long before the Inca period; we may therefore safely regard the *inti-huatanas* as primitive sanctuaries.

THE ELECTRICAL TRANSMISSION OF INTELLIGENCE.

By Thomas D. Lockwood.

THERE can be no time more fitting than the present for a review of what has been done, and an attempted forecast of what yet remains to be done, in the electrical transmission of intelligence. The jubilee of the establishment of commercial telegraphy in America is close at hand, the first Morse line having been completed between Baltimore and Washington in May, 1844.

Telegraph lines were built and operated in Germany and England by Steinheil and Cooke & Wheatstone, respectively, before the construction of the first Morse line in America. It is noteworthy that the system of Steinheil comprised a magneto-electric sending generator, a capillary ink-writer and a conventional alphabet of dots, and that the Cooke & Wheatstone plan comprehended a current-reversing transmitting-key and a needle deflecting receiver, which indicated its messages by transient signals also formed from an arbitrary code and addressed to the eye alone.

The Morse system consisted of an electric circuit containing a battery, a key to make and break the circuit, and a receiving register which, by means of clock-work, advanced a strip of paper on which dots and dashes composing the characters of the Morse alphabet were embossed by a stylus actuated by an electro-magnet, in response to the operation of the key at the distant station.

In order that a relatively weak main-line current might be used, and battery-power economized, a fine wire receiving magnet called a relay, provided with a light and easily-moved armature, was placed in the main circuit to respond to the key ; its function being to control by the movement of its armature between suitable stops or contacts, a short circuit in which flowed the much stronger current of a local battery, which circuit also included the magnet coils of the register. By employing this device the work of the main current was made easy and consisted in merely opening and closing a light supplementary key.

The story of the telegraph in America prior to 1866, when the scattered systems of the country coalesced into what is now the Western Union Telegraph Company, has no special interest for us to-day, and may be dismissed after brief notice. There had been no uniformity of practice in either construction or operation, and little material advance had been made save in the matter of physical expansion.

Though real advance prior to this time had been scant, invention had been prolific. The ingenious minds of a score of self-educated electricians had evolved as many forms of automatic repeater, by means of which, applying the principle of the relay, direct working might be effected between points too far distant to be connected by a single circuit, the sounder-lever of one line serving as the sending-key of the next. Reading the Morse code by sound had become universal, except in small country offices where students and neophytes were perennial. The House and Hughes type-printing telegraphs had waxed and waned ; the Phelps combination printer, an instrument embodying the best features of both of its predecessors and combining them with new ones of its own, had come into extensive use on certain lines ; and in New England the automatic chemical telegraph of Bain had evanescently atttempted to compete with the slower, but simpler and more trustworthy, key and sounder. Dial telegraphs, too, in which an electro-magnetically actuated pointer moved round a dial and spelled out words by halting an instant opposite the proper letters which were marked in a circle round the axis of the pointer, had to some extent been introduced in private telegraphs ; and let it not be forgotten that one cable spanning the Atlantic had been successfully laid as early as 1858, and had lived and worked after a fashion for twenty-six days.

The history of the telegraph systems of foreign countries is not dissimilar. Reasons of the same character retarded their physical progression and at the same time stimulated invention, but the consummation in a majority of instances turned out to be State control instead of corporation consolidation.

Ocean telegraphy, regarded by many in 1865 as a veritable *ignis-fatüus*, has long been an accomplished fact ; and communication between the old and new worlds, having been finally established in 1866, has ever since been maintained practically without interruption ; the speed of transmission meanwhile having raised from ten to twenty-five words per minute. This achievement was no ordinary one, and is one of which the Anglo-Saxon race on both sides of the Atlantic may justly pride itself. Besides having proved an immense convenience in the transmission of intelligence generally, the successful establishment of transatlantic cable communication has revolutionized methods of business, and has imparted a celerity and directness to diplomacy well suited to American tastes and tendencies.

Perfect insulation in land lines, once practically ignored, is now universally regarded as one of the essentials of successful telegraphy,—at least in theory. We fear, however, that practice does not fully keep pace with conviction,—on the western side of the ocean, at any rate.

Marked improvement has been made in insulating media and compounds; and cable-manufacture, which is still practically a monopoly of the English, has reached the dignity of a fine art.

With the great influx of business everywhere attendant upon the increased popular acquaintance with the telegraph, and upon the growth of trade and commerce, came the vital question: How shall we get more work out of our wires? How best shall we work them up to their full capacity?

This has been answered in various ways. The duplex and quadruplex methods of transmission have been introduced, and have solved the problem in part by enabling a plurality of messages to be sent over one wire at the same time without interference. Multiplex telegraphs, operating by putting the same main conductors successively into contact with a number of independent terminals at both ends, have also come into use. The main difficulty in the way of employing these was that of keeping the transferring mechanism at the two ends synchronized; but this having been accomplished by Delany, the multiplex is being successfully operated in England. Wheatstone's automatic system answers the question in another way: by transmitting communications much faster, but in single file, over the same wire. In this system success has been reached by substituting for the electro-chemical receiver of Bain and others an electro-magnetic ink-writer. This automatic apparatus does excellent work in both England and America, especially in sending press matter, or where much of business is to be sent over a single wire; and under favorable conditions, and on lines which are not too long, it is capable of transmitting 600 words per minute.

Type-printing telegraphs are still extant, being employed in France, and on certain lines in the United States. The apparatus employed in the latter country is a highly-organized machine known as the Phelps electro-motor telegraph, in which the moving mechanism is actuated by an electro-motor, the principle of operation being the synchronous action of the transmitting shaft and type-wheel arbor. The type-printing telegraph is likewise utilized in distributing commercial and financial information to brokers and merchants in cities; a number of receiving instruments, popularly termed "tickers," being connected in serial circuit with a single central-station instrument, and placed in subscribers' offices.

Entering other fields of usefulness, the telegraph gives warning of our fires, summons our messengers, and informs us of burglarious visitations; the bye-uses of the telegraph are becoming constantly more numerous and important. One of the brightest signs of the times in telegraphy may be found in the universal recognition of the advantages of systematic electrical measurement and scientific testing, both for maintenance and in the detection of faults, and in its well-nigh universal practice, which has indeed reached its apotheosis in the telegraph system of far-away India.

An important and valuable improvement is the employment of the dynamo for telegraphic circuits in many of our large cities. An advance equally important is the tendency towards the use of copper line wire.

We need scarcely look in the near future for radical and striking telegraphic inventions, but in view of past experience* we may reasonably expect a tremendous expansion in lines and business ; a wider employment of the two last-named improvemants ; a considerable increase in city underground work ; the operation of longer individual circuits ; far-reaching improvements in methods of collecting and delivering messages, perhaps by the increased employment of the pneumatic tube ; additional speed in the operation of submarine cables ; more press-matter transmission ; and gradual changes in practice accruing from the introduction into the telegraphic service (which must ultimately open its ranks for their reception) of trained scientific electricians and engineers.

We hear constantly of the desirability of government ownership of telegraphs. To a candid and impartial thinker there is little in the idea which commends itself. Our party politics is still too unregenerate, and although the spoils system has sustained rude shocks, its spirit is still too rampant and aggressive to permit of a belief in the able, honest, and independent governmental control and management of such an engine, when manned and officered by the party happening to be in power. Things are better as they are, especially as telegraphy is low-priced, and as what we buy is really worth what we pay for it. Let us wait at least until politics is so purified, and technical administration so stable, that a change in party control involves no greater change in governmental machinery than a change of cabinet officers and their immediate assistants ; and until competency and efficiency shall be universally held to constitute, for the working forces in all departments, a full and valid title to position, permanency, and preferment.

THE speaking telephone belongs to the history of our own times. In March, 1876, there was not a speaking telephone in the possession of the public and not a telephone line in existence. Yet telephonic transmission in eighteen short years, has brought into use in the United

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* Between 1866 and 1892 the wire mileage of the Western Union Telegraph Company alone rose from 76,000 to 750,000 miles ; its offices increased from 2000 to 20,000, and the yearly number of messages transmitted rose from 5,000,000 to 62,000,000. T. D. L.

States alone (in round numbers), 568,000 telephone transmitters and receivers, while the rest of the world employs about 580,000 more; and is furthermore to be credited with about 1,000,000 miles of telephone line wire, half of which, speaking broadly, is in the United States.

The telephone is like the telegraph in that the operation of both involves certain essential features: a source of electrical energy, a conductor through which this energy may travel from one point to another, and proper apparatus for delivering the message to the electrical messenger at one end of the conductor, and for enabling that messenger to tell the story at the other. But notwithstanding these similarities, telephonic and telegraphic transmission are things distant from one another, the former standing as completely alone and without peer as did Adam, among the four-footed associates of his garden, before the advent of Eve.

The relation of the telephone to the telegraph is that which the human voice, perfect in every articulation, bears to the deaf-and-dumb alphabet; and for this reason alone the achievement of the electrical transmission of speech must be regarded as the veritable capstone of the present century of discovery and invention.

The transmitter of the speaking telephone may be one which actually generates its own working currents in the act of transmitting speech, as in the magneto instrument; or it may be one which, as in the variable-resistance instrument, operates upon a current already provided—say by a battery—and which, in the act of transmitting, molds the ready-made current into the desired character. We may compare the action of the former to regulating the action of a steam-engine by generating more or less steam in the boiler, but admitting always such amount as is produced; and that of the latter to regulation by means of a throttle-valve, the original amount generated being always the same.

But whatever form of transmitter be employed two conditions must be observed: the transmitter, in order that it may exercise a constant control over the receiver, must have a circuit which is always unbroken, and the current flowing in this circuit must copy, electrically, the changes in the air produced by the spoken words in the vicinity of the transmitter.

It is not the number of vibrations per second, but the manner in which each is performed, that gives rise to the sensation of "quality," or the articulate character of sound. To transmit the "quality" and to reproduce the "form" of sound (which includes articulations), the transmitter must control the character as well as the frequency of the motions of the receiver. It can only do this by maintaining substantially a continual control over the current by which it lays hold of the receiver; and the speaking telephone does this by using in the transmitter a device which makes the electrical changes copy those of the air in character as well as frequency, and, in the receiver, a device which makes the motion in turn a copy of the electrical changes in form and in character, as well as in frequency.

The telephone, though extremely simple in construction, has been very little changed by the years of experience which have passed since it was publicly introduced. But it has required or involved an immense amount of auxiliary invention and adaptation, and the telephone apparatus now in the hands of the user is a highly-organized combination of really independent devices, capable of exercising independent functions which have been added to the telephone proper to meet as many different contingencies.

In addition to the instruments actually used in talking and hearing, it involves an alternating-current generator to produce calling currents; a polarized bell to announce the call; a switch, acting by the removal and replacement of the receiver, to transfer the line between the call-bell and telephones, and to open or close the transmitter circuit; a battery to furnish the initial current which is to be acted upon by the transmitter, and an induction coil associated with the transmitter, serving as an electrical lever and giving the transmitter a wide range of resistance within which it may be effective.

The generator coil is also to be ordinarily shunted out of circuit to protect it from dangerous currents or discharges, and, when located at intermediate stations, to prevent it from opposing by self-induction the voice currents which otherwise would have to traverse its coils; to open this shunt circuit, a special circuit-breaker is required, for convenience arranged to be operated by the act of turning the crank to send the call.

The most modern telephone lines are built of metallic or two-wire circuits, and the two conductors are placed as close together as practical conditions will permit. The reason is twofold: the telephone current is the smallest current known which performs any useful effect, and an instrument responding to so feeble a current must be and is extremely sensitive. But, being so sensitive, it is very subject to be disturbed by stronger currents straying upon its circuit.

These stray currents sometimes come by way of the earth connections conductively, and of course cannot appear when a metallic circuit is employed; sometimes, however, they are induced within the telephone circuit by currents traversing neighboring circuits, and in that case the disturbance is quelled, not because the circuit is all of wire, but because its two wires are close together and joined at the ends, so that the disturbing currents induced in the two wires, being of equal strength and of opposite direction in the telephone circuit, neutralize each other, leaving the telephones undisturbed.

Telephonic transmission is known to the world mainly through the telephone exchange; indeed, the public seem to have reached the conclusion that the telephone and telephone-exchange service are one and the same thing. It is evident that a telephone whereby I can communicate when I please with 5000 persons, and they with me, differs immeasurably from an exactly similar instrument which allows me to talk to but one or two particular persons only, and must be infinitely more valuable. It is also evident that in paying my exchange subscription I am not paying for a telephone, but for what I can get out of my telephone; for the economy of my time which it brings about; for the ability to find out whether the man I want to see is in, before I go to see him; for the hundreds of carfares and postage stamps I am saved from using; and for the convenience of talking to scores of persons without leaving my office,—no small convenience on a tempestuous day. Therefore not merely communication but intercommunication is the great field of force of the telephone, as is indeed manifested by the fact that nearly a thousand telephone exchanges are already in operation in the United States, and about as many more in other countries; and by the equally significant fact that 600,000,000 exchange-connections were made during the year 1892,—a number probably far exceeded in 1893.

The sub-station apparatus and the conductor of telephone-exchange circuits need not differ from those already described; but for the great business of the exchange—that of uniting lines for through conversation at the central station to which all lines converge—other appliances are required. These are combined mainly into a single instrumentality termed the "switchboard." By it calls can be received on annunciators and sent out by special generators; lines are united, conversation coached, and disconnecting signals received.

Each exchange line is fitted with one or more protective devices to forestall damage from electric-light or -power currents which may come on the telephone circuits by crosses with the conductors conveying them. In the great cities of the United States the telephone-exchange conductors, to a large extent, have been bunched in lead-covered cables and placed in underground conduits, there being at present some 350,000 miles of underground telephone wire in these cities.

Each cable conductor must be covered with some non-conductor throughout its length, and, as telegraphic and telephone currents inevitably travel with relative slowness and difficulty through subterranean or subaqueous cables, by reason of the retarding effects of static induction, it is highly desirable to so construct the cables that they will retain, in the manner of a Leyden jar, as little of the working currents as possible. So much success has been attained in this line of work that the cables now made have but about one-third the objectionable retarding and distorting effect that they had eight years ago.

For long-line work copper wire has been found even more essential than in telegraphy, and every long-distance circuit, to work efficiently, must be a two-wire circuit, and its material must be copper.

The birth of commercial long-distance telephony goes back no farther than 1885, but lines have already united the cities of the Atlantic seaboard as far south as Washington and have reached the western cities of Chicago and Cincinnati.

An interesting phase of telephonic transmission is that, by making certain arrangements of circuits, condensers, and electro-magnetic resistances, it becomes possible to send telegraphic and telephonic messages simultaneously over the same lines. This has been done to a limited extent with success, and the possibilities in this direction, as well as in that of multiple telephony proper, are very promising.

It must be evident from this brief sketch that an enormous amount of inventive thought has been devoted to the improvement of the telephone and accessory apparatus. This is further emphasized by the fact that since 1876, when the first telephone patent was granted by the United States patent office, there have been issued (up to the beginning of the present year) 805 patents on speaking telephones, and 2235 patents relating to calls, systems, switches, special conductors, cables, and other telephonic appliances.

Such is the past of the telephone. We can but guess at its future. No doubt private lines with cheaply-made telephones will increase rapidly, and that the great mass of the people will become educated in the use of the telephone. In a few years, perhaps, we hope to be as familiar with duplex telephony as we now are with duplex telegraphy. The long-distance lines doubtless will continue in future, as in the past, to exert a salutary influence over local work, raising its character and improving its facilities. It probably will be found that there is plenty of room for both telegraph and telephone to work harmoniously side by side, and that the character of their business will be so dissimilar that each will feed the other.

The telephone will be extensively used in departments of work where it has, so far, merely dabbled in the shore waters, as it were, and will be increasingly employed in mining and diving operations. It will be utilized in the military and naval operations of the future, both in the transmission of conversation and as a telegraphic receiver, in which latter capacity it will also be found generally acceptable. Perhaps it may find new fields of work in the permanent establishment of communication with moving trains, lighthouses, and even with vessels in mid-ocean ; but so far as the last is concerned let us hope not, for that is now the only retreat from the cares of the world.

The hotel of the future will not be considered complete unless its rooms are provided with telephonic facilities for connecting them with each other, with the office, and with the outside world ; factory systems arranged for the intercommunication of different departments will ere long be generally employed, and an office or a house fitted with a complete system of telephones will cease to be a rarity.

But telephonic transmission between London and New York, which some optimistic spirits are now discussing, I think will remain a subject for discussion only for many years to come, and need not be expected to reach fruition in time to be participated in by the writer or readers of this article on the electrical transmission of intelligence.

DEVELOPMENT OF THE INCANDESCENT ELECTRIC LAMP.

By John W. Howell.

THE incandescent lamp, though in such common use to-day, has been before the public only about fourteen years. The causes underlying the rapid growth in its use were the great demand for the light, which grew steadily as its peculiar advantages became better known, and the interest which was awakened in the minds of many workers by the problems which arose in great numbers in connection with the lamp itself and with the apparatus and appliances made necessary by its introduction into new fields. The development of incandescent lighting has called for the best efforts of master minds in many departments of scientific and technical investigation, and the attractiveness of the work has kept the interest of the workers keenly alive.

The incandescent lamp produces light without flame and with very little heat, with no consumption of oxygen or production of undesirable products, and with an utter disregard for surrounding conditions. These qualities render the incandescent lamp peculiarly suited for lighting very many places where other lights are inconvenient or dangerous. Thus it can be used in the presence of explosive gases or ignitable substances, as in coal-mines, oil-refineries, chemical works, and powder-mills. In cotton- and woolen-mills, and other factories where the product is at times in an easily ignitable condition, this lamp can be used in closer proximity to the work than can a flaming lamp.

The comparative absence of heat, besides being a blessing to all users in hot weather, is of special value to dentists and surgeons. The fact that the lamps consume no oxygen, thus yielding no disagreeable products, renders them peculiarly suitable for use on vessels where ventilation is often a difficult problem. Their adaptability is another cause of their popularity. The advent of these lamps has rendered artistic and decorative lighting possible. Who has not looked into a show-window lighted with concealed lamps and admired the effect? How many people have spent an hour in the dining-room at the Waldorf Hotel in New York without noticing that the candles on the tables were indeed candles, while the candles on the walls were miniature incandescent lamps?

People are so accustomed to the beautiful and wonderful adaptation of incandescent lamps that they evince surprise at nothing, and satisfy their minds with the explanation that it is done by electricity,—a magic word that explains all mysteries and makes everything possible. It has indeed rendered possible many achievements impossible without it, but the work has been done by man, aided by electricity, and not by electricity aided by man. It is man's servant by conquest; not nature's gift to the indolent.

Volta's discovery of the battery, in 1800, placed at man's disposal a new form of energy which at once received the attention of investigators. The transformation of electric energy to the other well-known forms was soon accomplished, and heat, light, and mechanical power were produced from electricity.

Sir Humphry Davy, in 1808, constructed a very large battery. In his experiments he produced the electric arc between carbon points and electrically heated to incandescence platinum and other wires, and carbon. The effects produced by the new and invisible form of energy were subjects of much investigation. Metallic wires and pieces of carbon were heated to incandescence in the open air, and in globes which were exhausted, or filled with different gases at various pressures.

Very early in the history of the subject we had in name, but in name only, all the elements which enter into the modern incandescent lamp. We had the carbon burner, the vacuum, and the glass globe with its leading-in conductors. While these elements existed in name in the apparatus made by Davy, they did not exist in the perfection necessary for a successful incandescent lamp. The best vacuum obtained at that time was not a vacuum in the sense in which the word is used in connection with incandescent lamps to-day. The globe which contained Davy's incandescent carbon was not suitable for the protection of a vacuum under the conditions of use as an incandescent lamp. The carbon conductors which Davy heated to incandescence would not have proved durable for any great length of time.

There are four essentials in the successful modern incandescent lamp: the vacuum, the glass globe, the carbon burner, and the conductors which carry the current through the globe. All these elements existed in name in the apparatus of Davy. The development of the lamp has not called for the discovery or introduction of any new element; it is simply the development of the elements which existed in Davy's apparatus, and their arrangement in a combination in which the laws governing them and their relations to one another are appreciated and intelligently applied. The large batteries, which were the sources of the currents employed by Davy, were expensive to make and maintain, and were to be found only in a few large and well-equipped laboratories. Soon new forms of batteries were discovered, and the magneto-electric machine was invented, cheapening the production of currents.

Practical and commercial applications of the new phenomena are the subjects of the patents which form so large a part of the records of the history of electric-lighting. From the lamp patented by Starr in 1845 to the lamp of Sawyer and Man in 1879 very little progress was made toward the final solution of the problem, except in the carbon burner. The extreme simplicity which characterizes the modern incandescent lamp, and to which its success was largely due, was more nearly approached in the Starr lamp than in many subsequent lamps.

Starr's lamp is worthy of special attention. The carbon burner was contained in a bulb blown on the end of a barometer-tube. This bulb and tube were filled with mercury, and air and moisture were driven out as was done in making barometers. The tube was then inverted in a cup of mercury, leaving a Torricellian vacuum in the bulb at the top of the tube. One of the conductors which carried the current to the burner was a platinum wire sealed in the top of the bulb by fusion of the glass. The other conductor was a wire which dipped into the mercury in the tube. The support for the burner was a simple piece of insulating material.

Let us study in this lamp the four elements whose development we are tracing. The carbon burner was made of gas-retort carbon, which, although difficult to make into thin pieces, is a very hard and dense carbon. It was the best carbon known to the art at that time; indeed, its nature is similar to that of the carbon deposited on modern filaments by the hydrocarbon treatment. The glass bulb was a simple one. It was made of thin glass, which was advantageous. The open end was closed by mercury more tightly than many subsequent lamps were closed. The one platinum conductor which was sealed in the glass illustrates the method of carrying the current into the lamp which is in almost universal use to-day.

The Torricellian vacuum in this lamp was at that time considered a perfect vacuum, and was a practically good vacuum until the lamp was operated. But when the lamp was burned gases were driven by the heat from the interior parts of the lamp, which impaired the vacuum and soon rendered the lamp useless. The lamp, when in use, was still attached to the barometric tube by means of which it had been exhausted, and when the lamp was operated the depression of the mercury in this tube showed that gases were liberated within the lamp. This was a fatal defect, and the method of exhausting offered no remedy for it. Modern lamps are exhausted by means of vacuum-pumps which draw from the lamp-chambers all air and other gases. When the air has been withdrawn, the lamps, being still connected with the pumps, are burned, and the gases, liberated by the heat, are drawn from them by the pumps.

The difficulty of producing a vacuum good enough to render carbon stable at a high incandescence caused many inventors to prefer platinum as the material from which to make the burners of their lamps. It also led to the invention of several lamps in which the carbon, when consumed by the air necessarily remaining in the lamp, was replaced automatically by another. Some of these lamps had several carbons. The lamp patented by Konn in 1875 was of this type, and was probably the most successful lamp made up to that time. It had five carbons. This lamp had a limited commercial use. The first carbon was consumed almost immediately when put in use, and each subsequent carbon lasted about two hours. The mechanism in these lamps increased the amount of gas liberated in the lamp by the heat, and increased the difficulty it was intended to remedy.

The consumption of carbon in the best vacuum that could be produced led many inventors to fill lamp-chambers with a gas which would not combine with the incandescent carbon. The lamps made by Sawyer and Man in 1879 were filled with nitrogen gas. These lamps, during the process of filling, were burned, while this gas was passed in a stream through them, and the gases liberated in the interior of the lamps by the heat were thus washed out and the lamp-chamber left full of nitrogen. The heat-conducting power of this gas caused these lamps to get heated, and means of cooling them had to be found.

Every lamp before 1878 was made in separate parts. This construction was made necessary by the short life of the burners, which necessitated their frequent removal, and by the liability of the mechanism to get out of order. The parts of these lamps were cemented and clamped together, and methods of making such joints tight were subjects of invention. Before this time pumps had been invented which were capable of producing a nearly perfect vacuum, but incandescent-lamp inventors had not availed themselves of them.

The best lamps produced up to 1879 had two features which rendered them unsuited to the maintenance of a high vacuum. The large amount of mechanism which they contained would liberate gases when the lamps was burned ; and the joints between the separable parts of the lamp were almost of necessity a source of trouble from leakage, as it was difficult to make such joints tight in a structure which was heated and cooled frequently. Thus the two lines which had been followed by inventors in their efforts to remedy the evil effects of an insufficient vacuum had removed the lamp-chambers further and further from the simple all-glass bulb which characterizes the successful lamp of to-day.

When we consider that all inventors, whether they used a series of burners or one burner in a lamp having a vacuum or containing an inert gas, recognized the necessity of making the lamps in separable parts, we admire the boldness of Mr. Edison in reducing the lamp to elementary simplicity, putting inside the lamps nothing but the carbon burner and short conducting wires, and making the chamber entirely of glass sealed at all points by fusion. Such a lamp-chamber would maintain a vacuum. There is no joint in this lamp at which leakage can occur, and the leading-in conductors are sealed into the glass so that no leakage can occur where they enter. They cannot be taken apart to put in new burners; consequently they must burn so long that when they do break the user is satisfied to throw them away.

Having traced the development of the lamp-chamber, let us consider the carbon burner. The early experimenters naturally used pieces of charcoal, which was readily consumed, as it oxidizes at a low temperature. Pieces of gas-retort carbon were found to be more durable, and Starr used the latter in his lamp. It is hard to work to the desired size, but is denser and harder than charcoal and requires a higher temperature to oxidize it. The difficulty of making these burners led experimenters to devise methods of making artificial burners. In 1857 Charles W. Harrison made carbon burners by suspending pencils of charcoal in a retort which was filled with gas and heated to a high heat. This deposited a layer of gas carbon on the charcoal, which made it very hard. This process was also used by Sidot in 1870 and by Gaudoin in 1877. Gaudoin also made carbon burners by carbonizing pieces of wood of the shape and size desired, which were soaked in syrup, and recarbonized, several times. Carré, in 1876, made carbon rods and pencils by grinding different kinds of carbon together, mixing with syrup, molding and baking. He baked these carbon rods several times, soaking them in hot syrup before each baking. In 1879 Sawyer and Man immersed their carbon burners in a "carbon liquid" and heated them electrically while so immersed. This process deposits upon the burner a layer of very hard carbon. This is the best method known for making burners for incandescent lamps, and nearly all burners used to-day are finished by this process. The carbon burners used to-day upon which this treatment is applied are chiefly made of (1) silk threads, treated to harden them; (2) bamboo cut to the desired size; or (3) cellulose, which is dissolved, treated chemically, and made into pieces of the desired size. Each of these materials must be reduced to carbon by baking at a high temperature. The advantage which one of these may have over another lies in their adaptability and the ease with which they may be made of the desired size. Many filaments used to-day are only five one-thousandths of an inch in diameter, and to make such filaments in large quantities requires a base material which is homogeneous, and which can be conveniently carried through the necessary processes of manufacture. Filaments made of chemically-prepared cellulose, or of bamboo, have been used with fair success without being treated by the carbon-depositing process, but this process is necessary to secure the best results from any carbon base.

This process is beneficial in three ways: it coats the base with a layer of very hard, dense, and stable carbon; it brings all the burners to a predetermined resistance, and it deposits gray carbon, which is a worse radiator of heat than is any other form of carbon which has been used for filaments of incandescent lamps.

The amount of light which a given burner yields in an incandescent lamp depends upon its temperature. The efficiency of the lamp depends upon the amount of energy which must be constantly supplied to the burner to maintain its temperature. The worse the heat radiating power of any burner, the less rapidly it is cooled by radiation, and the less the energy necessary to maintain its temperature or candle-power, as the energy supplied must equal the energy dissipated. The efficiency of a given burner depends upon the amount of surface which yields each unit of light,—the greater the surface per unit of light the less the efficiency.

Consider two burners of the same size, one having been treated and the other not. The treated burner, being the worse radiator, will yield a given amount of light with less energy or at a greater efficiency than the non-treated one. Consequently, if a treated and an untreated burner are to be made of the same candle power and efficiency, the treated burner must have a larger surface than the untreated one. Assuming that two burners are at the same temperature when they are yielding the same amount of light per unit of surface, we conclude that a treated burner is operated at a lower temperature than an untreated one at the same efficiency. And, being at a lower temperature, it should give a longer life, be more stable, and maintain its candle-power better. Thus the hydrocarbon treatment increases the stability of a burner by reason of the character of the surface which it gives, as well as by the hardness and density of the deposited carbon.

This deposited carbon has a much lower specific resistance than any other form of carbon available for incandescent-lamp filaments. This is a great advantage in making low-resistance burners and a disadvantage in making high-resistance ones.

The inventor of the hydrocarbon-treatment process did not understand that a bad radiating surface was desirable, but urged the good radiating power of carbon as one of its advantages over platinum. In 1879, Alfred Niaudet, a French phycisist of deservedly high repute, compared the radiating power of carbon and platinum, to the detriment of the latter, for use in incandescent lamps. In 1874, Wild, the director of the Russian imperial observatory, made the same comparison and drew the same conclusion. Exactly the opposite is the fact. If a stable coating of bright platinum could be applied to a carbon burner, it would be better in this respect than the coating given by the hydrocarbon treatment.

Thus far we have considered the incandescent lamp as an apparatus for converting electricity into light, without any reference to its relation to the system of distribution by which the lamps are supplied with current. With the exception of Lane Fox, no inventor of lamps prior to Edison appears to have considered the qualities which successful distribution require in a lamp. No carbon-burner lamp, before Edison made his, had that characteristic so essential to multiple-arc distribution,—namely, high resistance. The lines along which inventors previous to Edison had traveled precluded the possibility of their making high-resistance carbon-burner lamps. No lamp-chamber used by them was capable of successfully maintaining the high vacuum necessary to render filamentary high-resistance burners stable. The short, thick carbon burners which they used wasted away quite rapidly, and certainly a filamentary burner would have been consumed in a short time. Reasoning with a knowledge of the performance of lamps previous to Edison's, any one would be justified in pronouncing a filamentary burner a probable failure. Indeed, Edison's filamentary burner was made possible by Edison's all-glass lamp-chamber. There was practically no superfluous material in it to give off gases. Being closed at all points by the fusion of the glass, it would protect a vacuum indefinitely, and the duration of the lamp in use was limited by the stability of the carbon burner. The tendency of invention from Starr to Sawyer and Man had been to fill the lamp-chamber with mechanism. Edison went directly to the root of the matter, stripping the lamp of all unessential parts. The lamp made by Edison in 1880 and the lamp made to-day are different in details of manufacture only. Their appearance and general characteristics are the same.

An incandescent lamp is simply an apparatus for converting electricity into light. The laws which govern the lamp are the well-known laws of heat, light, and electricity. No new law has been discovered in connection with incandescent lamps. Edison was, I believe, the first to correlate these laws, and to make a lamp which, because of its harmony with these laws, was stable.

The multiple-arc system of distribution is the ideal one for operating incandescent lamps. It was by making his lamp of such high resistance and such small radiating surface that it could be used on such a system that Edison made his lamp a commercial success. But if we consider the lamp without any reference to any system of distribution, a very high-resistance lamp is inferior to one of lower resistance. The systems of distribution in general use to-day use lamps of two general voltages—115 and 55. The 115-volt lamps are of very high resistance. The 55-volt lamps are of lower resistance, and are superior to the 115-volt lamps. When this fact is more fully appreciated, lower-voltage lamps will be more generally used. By using lower-voltage lamps we can get the benefit of the advantages of the increased stability which these lamps have, and this will enable us to use lamps of fewer watts per candle than are required by the higher-voltage lamps.

The greatest development of the lamp since 1880 has been in its efficiency. The first lamps commercially installed by the Edison company required 6 watts per candle to operate them, whereas now well-regulated stations use lamps requiring only 3 watts per candle ; thus each horse-power produces twice as much light now as it could have produced in 1880. Progress is still being made in this direction. Every improvement in the quality of a lamp allows it to be operated at a higher efficiency, and it is in this direction that we look for future improvements.

THE PYRITIC-SMELTING PROCESS.

By Philip Argall, E. M.

THE greater part of the precious metals produced in the western United States are extracted from their ores by the smelting process, in which base metals are the vehicles used to collect the gold and silver contents of the ores and concentrate them in metallic lead, in a copper-matte, and sometimes in an iron-matte. The method of smelting employed in each particular case usually derives its name from the base metal used, or from the particular ore employed in the process of reduction; we have, therefore, so-called lead-smelters, copper-smelters, iron-matte-, and pyritic-smelters, though the principal object in each process is the extraction of the precious metals contained in the ores.

The Omaha and Grant Smelting Works at Denver, Colorado, may be taken as a typical example of a lead-smelter,* combining all the recent improvements. The output from these works for the year 1893 was: Lead, 20,865 tons; copper, 481 tons; gold, 90,213 ounces; and silver, 10,059,711 ounces, having a total value of $11,917,828. Now the value of the lead in this output is but $1,441,000, from which it appears that, for each dollar's worth of lead produced, over six-and-a-half dollars' worth of precious metals were unlocked from the ores and started on their mission of usefulness to mankind.

The Boston and Colorado Smelting Works, also at Denver, is probably the best example of a copper-smelter in the sense used in this article. The output from these works during 1893 amounted as follows: Copper, 5357 tons; gold, 61,102 ounces; and silver, 4,177,117 ounces, having a total value of $5,607,186. Of this amount but $1,071,478 was derived from the copper or base metal used to collect the gold and silver from the ores. Here, then, we see that each dollar's worth of copper produced gave an accompanying value of nearly $4.50 worth of precious metals.

Iron-matte smelting, or the reduction of raw or partly-calcined sulphid ores for the purpose of collecting the precious metals in an iron-matte, though not much practised in the west, has been conducted at various European works from a very early date. The German authorities show that one Barthel Köhler used this system of smelting at Freiberg as early as 1585. Dr. Percy, in his metallurgy of gold and silver, makes special mention of iron-matte smelting, and he shows that it is specially adapted to localities in which lead-ores are not procurable at a sufficiently low rate to justify lead-smelting. Such are the conditions that obtain at the famous Kongsberg mines, in Norway, and there iron-pyrite has long been employed in smelting the ores. It is added to the furnace charge to the amount of 15 per cent. of the ore smelted and serves to collect the silver in an iron-matte, which subsequently is desilverized by means of lead. The furnaces used at Kongsberg prior to 1847 had a capacity of only ten tons of charge per day. The pressure of the blast used was one-sixth of a pound per square inch, and the consumption of fuel in the furnace about 22 per cent. of the weight of the charge, the fuel being fir and pine charcoal. Iron-matte smelting has long been practiced at Sala, in Sweden, in Hungary, the Altai mountains in Russia, and in various other parts of Europe.

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*For a description of the usual lead-smelting process, see the very interesting article by Mr. Walter Renton Ingalls in the March number of this Magazine. P. A.

The first step in the Swansea method of copper-smelting is the production of a copper-matte, or copper-iron-matte, in reverberatory furnaces, from the partially-roasted ores. This is the method pursued to-day at the Boston and Colorado works, already referred to as a copper-smelter. It will be seen that in all these matte-smelting methods, both for iron- and copper-matte, the ores, if sulphids, are first calcined to drive off the excess of sulphur, or, if not sulphids, then sulphur is added, usually in the form of pyrite (as in the Kongsberg practice, for example), in such proportion that the resulting matte shall form but a small part of the total product of the furnace,—say 5 to 15 per cent. of the ore smelted. In this way the precious metals distributed in the ores become concentrated in an iron- or copper-matte. When sulphid ores are to be reduced by the lead-smelting process, they are first calcined to drive off the sulphur, and thus convert the sulphids of the metals into oxids.

Pyritic-smelting, briefly, is iron-matte smelting in blast-furnaces, but it differs from the ordinary matte-smelting in the fact that, in the latter, no attempt is made to utilize the calorific properties of the ores, while in the former the aim is to perform the entire smelting operation in the furnace by means of the heat evolved from the combustion of the sulphids. To the lead- and copper-smelter, pyrites and other natural sulphids are not the most desirable ores, though valuable, it is true, for their iron contents, but nevertheless requiring calcination before they can be smelted, and therefore demanding a more expensive treatment, which often results in a greater loss of precious metals than occurs in the smelting of oxidized ores.

To the pyritic smelter, however, natural sulphids, particularly iron-pyrites, are not only docile ores, but are also *fuel*, capable of being consumed in the furnace, smelting not only themselves, but also the fluxes necessary to form a slag of the desired composition. Pyritic-smelting, then, is intended to be a process of smelting without the use of carbonaceous fuel in the furnace. This at first blush seems impossible, and, though a theoretical examination of the process shows that it should easily be accomplished, yet in practice a small amount of fuel is often found necessary, particularly where the ores are not of the proper composition and character to give the best results.

It may not be generally known that pyrite can be burned in very much the same way as coal or other fuel, and that, when consumed under proper conditions, it can develop a temperature very little less than that produced by the best coal. Some persons who are, or should be, familiar with the combustion of pyrite assume that all the heat is derived from the sulphur. This is an error. The calorific power of 1 gram of mono-sulphid of iron, $Fe\,S$, is, neglecting that absorbed by the dissociation of the elements, about 1621 thermal units, of which 807 are evolved by the combustion of the sulphur, and 814 by that of the iron. The temperature produced by the combustion of mono-sulphid of iron is shown by calculation to be about 2200° C. Sulphid of zinc gives a temperature of about 2000° C.; lead sulphid, 1860° C.; while coal, containing 80 per cent. of carbon, 5 per cent. of hydrogen, and 15 per cent. of noncombustible matter, gives a combustion temperature of about 2700° C. It is important, however, to note that, while the combustion of coal apparently produces a higher temperature, in reality the sulphid of iron does more work in the furnace, for in the first case much of the heat produced is absorbed in expanding the gaseous products of combustion and associated nitrogen, whereas, in the case of sulphid of iron, the resultant product being mainly protoxid of iron, the heat generated is applied to a more essential purpose, the smelting of the ore. These facts are easily demonstrated by a calorific calculation, which the limits of this article will not permit.

It follows, then, that for metallurgical purposes these sulphids, particularly pyrite, can be made to act as fuel when the proper conditions for their thorough combustion exist in the furnace. Pyrite will burn under the ordinary atmospheric conditions, and give out considerable heat. The heap-roasting of pyritic ores is a familiar example. This process is conducted on an extensive scale at Sudbury, Canada, where large heaps of the niccoliferous pyrrhotite are set on fire, and burn for considerable time, the object being to drive off the sulphur and prepare the ore for the subsequent smelting operation. At the pyrite-mines in Spain heaps of many thousand tons are set on fire and burn for a period of five or six months, with the evolution of immense quantities of sulphurous-acid gas. This practice will, however, with the introduction of pyritic-smelting, be relegated to the oblivion of the barbaric methods of metallurgy. For apart from the destruction of valuable fuel and the locking up of large stocks of ores for long periods of time, it also results in destroying the vegetation and soil, producing a general appearance of desolation and decay in the neighborhood of the works.

Another familiar example is the burning of pyrite in kilns for the manufacture of sulphuric acid from the gases given off. In these kilns the pyrite is burnt at a cherry-red heat at the rate of about forty pounds per square foot of grate-area, or, say fifty square feet of grate-area per ton of ore burnt per day. A modern pyritic-smelting furnace would easily consume 100 tons of pyrites per day in the same area. Now as temperature is, within certain limits, directly proportional to the amount of fuel consumed on a given area in a given time, one will readily see, by analogy, the enormous temperature that can be produced by the oxidation of pyrite in such quantities. In this way, the possibility of pyritic-smelting becomes manifest even to the uninitiated.

From an examination of the available literature of the subject I am led to the conclusion that the inception of smelting pyrite by its own combustion came long after Bessemer's invention for the direct manufacture of steel, by means of blowing air, divided into numerous jets, through a bath of molten cast-iron, thus effecting the rapid oxidation, or combustion, of carbon, silicon, and certain other substances present in pig-iron. In this process it is obvious that the high temperature developed in the converter is the result of the intimate contact between the air and various oxidizable bodies present. To substitute a molten copper-iron-matte in the converter for the cast-iron, and to oxidize the iron and sulphur of the matte, producing "black copper" in one operation, would appear to be a natural development of the Bessemer idea, and one that, at the first glance, appears to be very easily carried out. Nevertheless, the first experiments in this direction, made in Russia in 1867, resulted in complete failure, as did also the attempts of Mr. John Hollway to smelt pyrite in a modified Bessemer converter, in England, in 1879. M. Pierre Manhès, however, in 1881, succeeded in the bessemerizing of copper-matte, overcoming the difficulties of the earlier experimenters, and established his process on a working basis in France. This Manhès process, with various modifications and improvements, is now very extensively used in this country for the treatment of copper-mattes—of low contents in precious metals. I look upon the Manhès process as pyritic-smelting carried to a conclusion by the more or less complete oxidization of the iron and sulphur, and the production of almost pure copper (98 to 99 per cent. fine) from the ordinary copper-matte.

Returning to pyritic-smelting proper, the experiments of Hollway proved that it was possible to smelt pyrite by means of the heat developed through its own combustion. But many obstacles and difficulties were encountered, some of which proved insurmountable, and in consequence of which continuous smelting could not be carried out in the apparatus then used. And while the experiments excited much interest at the time, it was generally conceded that as a commercial system of ore-reduction the whole process was a failure.

Mr. W. L. Austin, of Denver, for some years past has given this subject of pyritic-smelting much thought and attention, subjecting his methods to careful and thorough tests on a working scale, until he has succeeded finally in overcoming the difficulties encountered by the earlier workers in this field, and, with the aid of the most modern improvements in metallurgy, has built up a system of pyritic-smelting that has taken firm root in Colorado, and has become a great industry in the land.

The furnaces used in carrying out the Austin system of pyritic-smelting closely resemble the blast-furnace used in lead-smelting; differing, however, in some essential particulars which are necessary to fit it for the use of the sulphids as fuel instead of the carbonaceous material employed in the lead-furnace. The capacity of the pyritic furnace is, however, from 30 to 50 per cent. greater than that of a lead-smelting furnace of the same dimensions. This may be partly explained by the fact that in the former the ore and fuel are united in the one substance, *pyrite;* consequently no space is occupied with coke, nor is any time wasted in burning this bulky material.

The *modus operandi* of a pyritic furnace consists in feeding the raw ores and fluxes in pieces as large as can be conveniently handled —and of course, of the proper composition to form the desired slag— and drawing off the products of the smelting operation, matte and slag, either continuously, as in the case of large furnaces, or at regular intervals in the case of smaller ones. The matte resulting from the first smelting is usually put through the furnace again, together with rich silicious ores. This matte is, if anything, a better fuel than the raw pyrite, and by this second process it is concentrated to a very high value in precious metals, and is then shipped to the refiners. It is, of course, understood that the raw, unroasted pyritic ores are used in the pyritic-smelting furnace, while in other smelting processes such ores must be calcined—often at great expense—before they can be smelted. In the pyritic process, then, the ores are, as it were, roasted and smelted in one operation, at a cost very little in excess of roasting the ores by hand labor.

A word explanatory of the theory of this interesting system of smelting may be permissible. As the pyrite, $Fe S_2$, descends the shaft of the furnace, one atom of the sulphur is expelled when the zone of dull-red heat is reached. This atom, on meeting the air at the surface of the charge, burns, with the characteristic sulphur flame, to sulphurous acid, $S O_2$. The pyrite, then, deprived of its extra atom of sulphur, reaches the zone of fusion as mono-sulphid of iron, $Fe S$, and here it is immediately oxidized by the highly heated air-blast to ferrous oxid and sulphurous acid. The former, combining with the silica, forms a slag of ferrous silicate, while the latter ascends the stack with the other gases. As there is always more mono-sulphid present than can be oxidized by the blast, the sulphur runs down in the form of iron-matte, which contains practically all the precious metals carried in the furnace charge. If the furnace is worked with a closed top, sulphuric acid can be manufactured as a by-product from the gases evolved from the smelting operation.

In lead- or copper-smelting, ores rich in these metals are smelted for a moderate price per ton, while the ores that require the addition of lead or copper to the furnace charge, in order to beneficiate them, are naturally subject to a much higher rate of treatment. The supply of such ores in Colorado has been for some time in excess of the available quantity of lead- and copper-ores necessary to treat them. Leadville, for example, for many years the center of the lead-smelting industry, and even now the greatest producer of lead-fluxing ores in this country, did not yield sufficient lead last year to treat more than one-half her own output. It would therefore appear that there is a good opening in Colorado for a smelting system that can reduce " dry " ores without lead or copper, or with but little copper. Such a system is found in pyritic-smelting, by which the precious metals are reduced from their ores by means of the very common, cheap, but nevertheless useful, metal, *iron*.

Pyritic-smelting is not only applicable to the reduction of the ores of the precious metals, but it can also be applied to the treatment of niccoliferous pyrrhotite, or cupreous pyrite. The raw ores in each case would be fed direct to the furnaces together with the necessary fluxes, the resulting matte could be drawn off into converters and blown until the desired concentration is reached. The whole process of making black copper from the ores should not, under favorable conditions, and conducted on a large scale, exceed $2.50 to $3 per ton of ore treated.

Pyritic-smelting is comparatively new in Colorado. It is just two years since it was introduced at the La Plata smelter at Leadville, yet we find two works running under this system last year, treating, according to the published statements, over 55,000 tons of ore, producing therefrom 494 tons of copper, 6165 ounces of gold, and 1,224,026 ounces of silver. The product of these works is, as we have seen, an iron-matte containing some copper. Now, as the iron in the matte is of little commercial value, it is not estimated in the yearly statement. Taking the copper for comparison, however, we find that, for each dollar's worth of this metal produced, over $11 worth of precious metals were collected from their ores, against 6½ to 1 in the typical lead-smelting example, and 4½ to 1 in the copper-smelting example given herein.

A process that can obtain such remarkable results within two years of its introduction into a state that holds the proud position of leading the world in the metallurgy of the precious metals, shows at once its great metallurgical value as well as its economic importance. And it augurs well for its successful introduction into other countries less highly favored with smelting-works than Colorado, but which have more extensive deposits of available metallurgical fuel in the form of pyrite. This ore occurs in almost every mineral vein, is more or less abundant in every country, and is now through this process rendered valuable, both as a fuel and as a vehicle for smelting and collecting the precious metals from their ores.

THE BEET-SUGAR INDUSTRY IN THE UNITED STATES.

By Harvey W. Wiley.

THE beet-sugar industry in the United States is in its infancy, there being only seven manufactories of this product in operation in the country. The oldest of these, at Alvarado, California, was erected about fifteen years ago and has been operated every year since. The factories next in order in seniority are those at Grand Island, Nebraska, and Watsonville, California. Still younger than these, by one year, are the factories at Norfolk, Nebraska ; Lehigh, Utah ; and Chino, California. The youngest and smallest of the factories, located at Staunton, Virginia, has been operated only one season. The increase in the rate of beet-sugar production in the United States during the past few years is shown as follows :

	Pounds.
In 1887	600,000
In 1888	4,000 000
In 1889	6,000,000
In 1890	8,000,000
In 1891	12,004,838
In 1892	27,083,288
In 1893	43,648,797

The next table gives the production, during 1893, at the different factories, as follows :

	Pounds.
Staunton, Virginia	36,458
Grand Island, Nebraska	1,835,900
Lehigh, Utah	3,750,000
Norfolk, Nebraska	4,000,000
Alvarado, California	4,186,572
Watsonville, California	14,500,000
Chino, California	15,039,867

The amount of capital invested in the seven beet-sugar factories is about $2,000,000. Tributary to these factories, under cultivation in beets, are about 20,000 acres of land. The value of this land has greatly increased since it has been used for beet-growing, especially near Chino, California, where the price per acre has become very high, as much as $200 having been paid in some cases. The cost of cultivating this land in beets is considerably more than $500,000 a year. The production of beet-roots for sugar-making purposes in the United States during the past year approximated 200,000 tons, and the average price paid to the farmers for this raw material was $4.50 per ton.

It will be seen that a large investment of capital in land and machinery and a large outlay of money for labor are needed to produce a little over 20,000 tons of sugar per year. It is not difficult to foresee the large amount of capital that would be absorbed, the immense amount of labor that would be employed, and the great extent of land that would be placed under cultivation, if even half of the sugar consumed in the United States were made from beets grown within the country. The yearly consumption of sugar in the United States is now approximately 2,000,000 short tons, while the total production of all kinds of sugar—beet-root, cane, maple, and sorghum—is about 300,000 short tons, showing that a little less than one-sixth of the total amount consumed is produced at home.

THE SUGAR BEET.

The manufacture of beet-sugar in this country is a matter for serious consideration. By reason of the restricted area suitable for the cultivation of sugar-cane it is not to be expected that, under the most favorable conditions, the production of cane-sugar in Louisiana, Texas, and Florida will ever largely exceed 1,000,000 tons. On the other hand, there are no limits to the possible amount of beet-sugar which can be manufactured.

The production of sugar-beets is of itself an art. The ordinary forms of agriculture cannot be used for this purpose. Sugar-beet culture is in every sense intensive, and not extensive, farming. High-priced lands can be used for sugar-beet culture on which it would be impossible to grow profitably the staple crops. Intensive culture, high

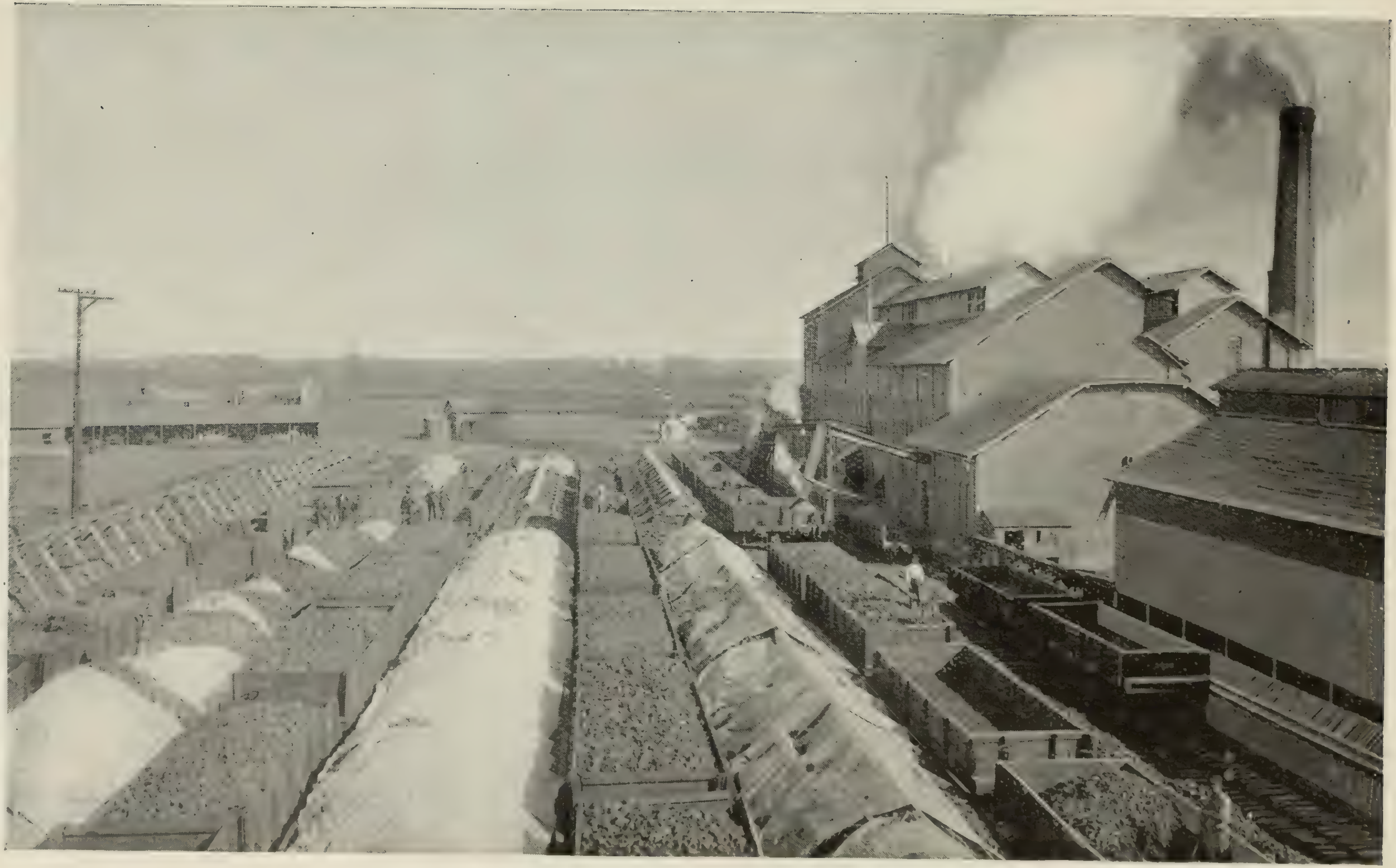
FIELD OF SUGAR-BEETS—CULTIVATING AND CLEARING.

fertilization, and scientific care in every respect characterize successful beet sugar culture the world over. The sugar-beet requires a deep mellow soil, perfect tilth, entire freedom from weeds and grass, and a great deal of hand-culture. The sugar-beet absorbs large quantities of water in its growth; it is fond of potash and phosphoric acid, and is not averse to nitrogen. It is a crop which should not be grown more than once in four years upon the same field, and this field, by judicious rotation and fertilization, is brought during this time into perfect condition again for the production of a maximum crop of beets. The establishment of beet-sugar culture in a community gives an object-lesson in the highest art of agriculture. It acts reflexively upon every other branch of agriculture, so that in countries which grow sugar-beets there are better crops of wheat and maize, of barley and hay; there are better classes of live stock, finer horses and cattle, and in general the whole tone and character of agriculture are elevated by reason of the influence, direct and reflexive, of the culture of the sugar-beet.

The sugar-beet has been brought to its present state of efficiency by the application of scientific principles of culture in the production of seed. The mother beets selected for seed the previous year are chosen on account of their perfect form and size. They are preserved during the winter in silos. In the early spring they are removed, and a diagonal core taken from each one is analyzed. The beets are in this way separated into grades: those showing above a certain percentage of sugar forming the *élite* or first grade, those falling within another class the second grade, with a third class lower, while all those which fall below the standard fixed for the lowest grade are rejected. Little has been done in this country in the way of the production of beet-seed, but for three years the United States department of agriculture has grown the highest-grade seeds at its station at Schuyler, Nebraska, in accordance with the principles set forth above. The careful experiments undertaken by the department at this station at Schuyler have shown that beets quite equal to the best grown in Europe are easily produced in the United States.

The manufacture of beet-sugar also represents the foremost advancement in mechanical improvement; it is a science of itself; it requires special machinery and apparatus, and its practice is a benefit, not only to the persons immediately engaged in it, but, reflexively, to the whole community.

The sugar-beets, which mature in September or October, are carefully harvested, and the foliage, with a portion of the neck of the beets, removed by a knife. Each beet must be handled separately for this purpose. A portion of the top of the beet is removed because that portion contains a large percentage of the salts found in the beet.



SUGAR-BEETS IN CARS AND IN SILO—FACTORY-YARDS, NORFOLK, NEBRASKA.

These salts—chiefly potash—exert a very injurious effect upon the sugar juices during the process of manufacture. They are bitter, they unite with any oil which the beet may contain and form soap, and they prevent large quantities of sugar from crystallizing.

The sugar beet, having been brought to the factory prepared as above, is first passed through a long trough by means of a screw, through which water flows in the opposite direction from the movement of the beets. The beets are thus thoroughly cleaned, all fragments of soil and pebbles being detached therefrom. Thorough washing is highly important, since the presence of sand, or soil, or grit of any kind upon the beets when they reach the cutting-machine rapidly dulls the knives and produces bruised and imperfect cuttings. The beets, having been washed, are elevated to a cutter immediately over the diffusion battery. This cutter is a horizontal disk carrying several corrugated knives. These knives slice the beets, usually into V-shaped pieces, so that, when placed in a tank, water may freely circulate among them.

The beet cuttings, called "cosettes" or "schnitzel," are next conducted to the diffusion battery,—a piece of apparatus designed for the extraction of sugar by means of the osmosis of the sugar-juices with the water which is brought into contact with the beet cuttings. The diffusion battery consists of from twelve to fourteen cells so arranged that a liquor can be passed at will from one to the other and drawn off from any one of them at any time. The hot water which is used for the extraction of the sugar passes from one cell to another, becoming more and more charged with sugar-juices. When it has passed through a sufficient number of cells,—usually ten to fourteen according to the size of the battery,—it reaches finally the cell last filled with beet cuttings, and from this it is drawn off into a measuring-tank. When the battery is once filled, its operation is continuous, one cell being filled with cuttings and the exhausted cuttings being discharged from another every time a portion of juice is drawn into the measuring-tank. The exhausted pulp is passed through a press by means of which a large portion of the water is forced therefrom, and the residue makes a most excellent food for cattle. This ration, however, is not a well-balanced one, and certain nitrogenous and fatty bodies are mixed with it in order to make a perfect food. Oil-cakes are very suitable for mixing with exhausted pulp for this purpose.

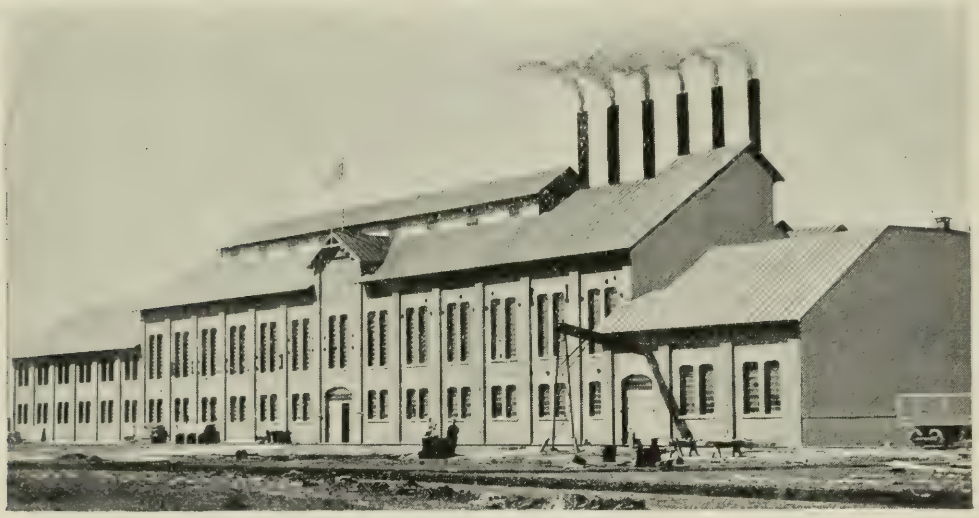
The sugar-juices, withdrawn from the battery as above mentioned, are passed into large tanks, where they are saturated with lime, from two to three pounds of which are used for each hundred pounds of juices. The temperature of the mixture is then raised gradually, and meanwhile a stream of carbonic acid is blown through the mixture.

FACTORY OF THE NORFOLK (NEB.) BEET-SUGAR CO., SHOWING FARMER'S APPROACH.

By this treatment the lime is precipitated as carbonate of lime, carrying down with it a large portion of the impurities originally contained in the beets. Beet juices, when first extracted, are usually of a dark, almost inky color. After treatment with lime and carbon dioxid in the manner above described, they are usually perfectly brilliant and of a beautiful amber tint. After the lime is all precipitated the juices are passed through filter-presses, on the cloths of which the lime and impurities are retained while the bright juices run through. A second treatment with lime and carbon dioxid is uniformly employed, and sometimes a third, in order to secure sugar-juices of high purity. The carbon dioxid used for this purpose is derived from a lime-kiln in connection with the factory, which also furnishes the lime necessary for the precipitation of the impurities.

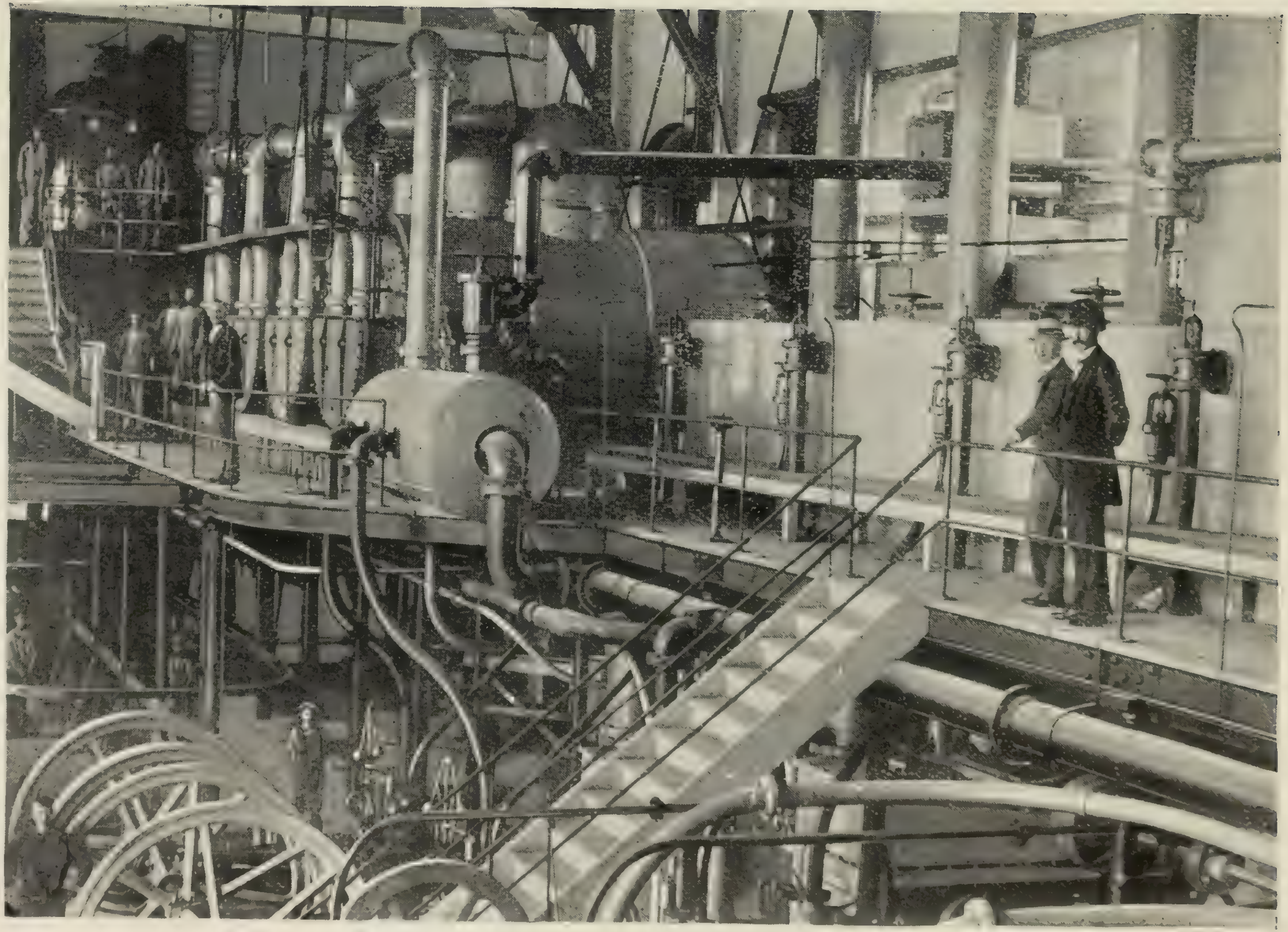
The purified juices, treated as above described, are next conducted to a multiple-effect evaporating apparatus. Here the juices are concentrated to syrup, the vapors from one of the multiple effects being used to boil the liquor in the second, and the vapor from the second being used to boil the liquor in the third. When this apparatus has two pans, it is called a double effect; when three, triple; they rarely contain more than four, while three is usually the number found.

The syrups, treated as above, if only raw sugar is to be made, are carried directly to the vacuum-strike pan. Small quantities of syrup are first taken into the pan and reduced to the crystallizing point. When fine crystals of sugar appear, additional portions of the syrup are drawn into the pan, continuously or from time to time, and the small microscopic crystals first formed begin to grow to the required size.



BEET-SUGAR FACTORY AT GRAND ISLAND, NEBRASKA.

[Capacity, 330 tons of Beets per day.]



INTERIOR VIEW OF BEET-SUGAR FACTORY AT GRAND ISLAND.

[Quadruple Effects and Tanks for Saturating with Lime and Carbon-Dioxid.]

This operation usually requires from three to sixteen hours, according as the pan is a quick or slow boiling one.

The sugar thus crystallized during the process of boiling is removed from the pan into a mixing apparatus, where it is thoroughly mixed by means of revolving arms. It passes then directly into the centrifugal apparatus, which, having perforated sides and revolving with great rapidity, quickly removes the molasses from the crystals, leaving the latter in a very dry form and suitable for transmission to the refinery.

In some beet-sugar factories the refining is done during the process of manufacture. In this case the syrups, before concentration, are filtered through bone-black or saturated with sulphurous acid. By these methods a pure white crystal of sugar is obtained, which, on being dried in a granulating apparatus after coming from the centrifugal, forms granulated sugar.

The molasses which is obtained by the above process is reboiled, and a second crop of crystals obtained therefrom. The molasses from this second crop of crystals is reboiled, placed in tanks, and left to stand for five, six, or even eight months, at the end of which time another crop of crystals, dark and mushy, has been formed, which can be separated by the centrifugals in the usual way, The final molasses, which contains a considerable quantity of sugar, is used either for distilling purposes, for fertilizing purposes, on account of the large amount of potash which it contains, or it may be subjected to treatment with freshly burnt and ground lime, at a low temperature, in which way the sugar which it contains is precipitated as sucrate of lime, from which the other impurities can be separated. The sucrate of lime can afterwards be beaten up with water into a paste and the lime precipitated with carbon dioxid as above described for purifying the juices. In this way almost all the sugar which was present in the molasses can be recovered.

The manufacture of sugar is a continuous process,—*i. e.*, the operations go on day and night. It is probably twenty-four or forty-eight hours from the time the beets enter the factory before the crystals of sugar secured therefrom appear, and the process is of such a nature that it cannot be broken except, usually at the end of a week or two weeks, when the house is shut down for repairs or renovation. An ordinary beet-sugar factory has a capacity for the consumption of about 250 tons of beets per day, and should make from 200 to 240 pounds of sugar per ton. In Europe larger factories are very common, capable of working from 400 to 600 tons of beets per day. In central factories there is a large number of diffusion batteries situated at different points, in which the juices are extracted. From these different places the juices are delivered to the central factory by means of pipe-lines, usually laid under ground. A central factory of this kind will be found able to take care of the juices from 1000 tons of beets per day.

Every one who desires to see the prosperity of American machinery, American ingenuity, and American agriculture should favor the development of the beet-sugar industry. There is no other way in which the plethora of agricultural products can be so readily relieved and renewed prosperity brought to our agricultural interests, thus stimulating every other interest in the land. The total consumption of sugar in the civilized world is not far from 7,000,000 tons, of which the United States uses two-sevenths. Of the 7,000,000 tons over 4,000,000 are made from sugar-beets. It is thus seen that in the race for the markets of the world the sugar-beet is already ahead of its most dangerous rival, the tropical sugar-cane. There is room, however, for both these sugar-producing plants, and there is reason to believe that with favorable conditions a great indigenous sugar industry, including cane- and beet-sugar, can be established in the United States.

THE GROWING IMPORTANCE OF THE ENGINEER.

By J. F. Holloway,

Past-President of the Engineers' Club of New York City.

To a close observer of current events, especially as they relate to progress in the industrial arts and in all that pertains to the convenience and comfort of the human race, it is perhaps quite unnecessary to say that engineering as a profession is steadily rising in the interest and the admiration of the world. Already the glowing light of a coming recognition of the usefulness of the engineer illuminates the hill-tops; already its cheering rays gild with glory the fame of those master minds who, in the past, did so much to make clearer the pathway and easier the road for those who were to follow in their footsteps. To-day the names of engineers who, in years gone by, labored and struggled amid discouragements and poverty that benefits might come to those who were to follow them, and who died in comparative obscurity, are now being enrolled high upon the temple of fame, where they are being brought into conspicuous notice by this increasing light of public appreciation.

As the world in its progress unfolds the future, and the labors and inventions of the engineer bring out of the crude material of nature new forces and forms of usefulness and beauty which shall, in the time to come as they have in the past, add to the happiness and comfort of all, the well-merited recognition of his aims and accomplishments will be heralded by that steadily-rising light until, ere it reaches its zenith, its rays shall crown in glowing splendor alike the highest and the humblest of the profession.

The great republic of France has for its president and chief ruler an engineer who has honored his profession by his wisdom, and who has so performed the manifold and difficult duties of his position as not only to have won the admiration of his countrymen and of the other republics of the world, but also to have received the homage due to his talents and manliness from the kings and emperors who surround him—who, from time immemorial, have held that the only road leading to such a position as he occupies was through an ancestry of royal blood.

Of late years there have grown into prominent existence national societies of engineers, who receive from the various cities to which they are invited from time to time such attention and entertainment as have never been accorded to other professions and societies. In nearly every prominent city in America local engineering societies exist and prosper, strengthening and aiding their members by meetings and the discussions of topics of local and national importance, while, by occasional gatherings devoted to the amenities of social life, they compel a recognition that would not otherwise be accorded to them.

What American engineer is there whose bosom does not swell with commendable pride, and who does not go his way with head more uplifted and with footsteps more firmly planted, as he remembers the honors and attentions shown to his associates when, as "American engineers," a few years ago, they made a triumphal landing on the shores of the old world—a world which but recently reserved its plaudits, its pomp, and its ceremonies alone for the soldier or the sailor as he returned victorious from battle and conquest? That peace, no less than war in these later days, has its victories, was well exemplified by the marked attentions bestowed upon this body of quiet, unpretentious "American engineers." Bearing no other emblems of distinction than those belonging to gentlemen, no passports beyond that of membership in an engineering society of the United States, no emblazonry of rank beyond that conferred by an unpretentious professional button or badge, they were, from the moment they touched English soil until they left it to receive similar attentions in other lands, the recipients of honors and courtesies such as never before were bestowed upon any body of men, other than crowned heads or their immediate representatives.

Fresh in the remembrance of all is that great White City, so recently and so quickly built along the shores of one of our inland seas, and within the limits of a city now second only in wealth, population, and importance in America,—a city whose foundations have been built within the memory of men now living. Fresh is the glorious memory of that adjunct White City—marvelous in its conception and execution, impressive and grand in everything that tends to elevate and ennoble—and when, in the time soon to come, it shall be to us the "vanished city of the plain," when its cloud-capped towers and gorgeous palaces shall have faded away like a dream, may the remembrance of its loveliness linger long with us to remind us what we owe to the able architects, who, coming together, putting aside all petty jealousies and rivalry, united to show the world what inspiration and imagination could conjure up, and what patient study and plodding industry could accomplish. While we cheerfully accord our just meed of praise to the members of a profession so nearly allied to our own, we do not lower our regard when we concede that it was only through the labors of the engineer and artisan, and by reason of what they had previously accomplished, that it was possible to present to the world the realization of what the architect and artist had so well dreamed of.

It would be invidious, if it were possible, to select the creation of one architect as being superior to that of another, or to describe in fitting terms the beauty that was symbolized in each of the magnificent buildings they produced. But I may say that, while from towering minarets and above massive domes pennants and banners proudly waved all the day long, first to catch the rosy tints of the sun as it emerged above the blue waves, and last to show its waning glory as it sank toward the horizon in the west, it pleased me most to note with swelling pride that it was upon the topmost pinnacle of the "Palace of Mechanic Arts" that the architect had made the angels to rest, and it was about the columns of the palace the engineer had filled with his creations that the wreaths of victory were entwined. Along the entablature they supported were written the names of engineers, many of them long since dead, but all of whom in their lifetime laid firmly the foundations upon which others since have builded so well. The massive engines beneath the roof, which had been gathered from many lands and which in their rhythmic beats turned the wondrous mechanisms there displayed, were but the refined exponents of the theories laid down by James Watt and others a hundred years ago.

No visitor to the fair who gave to the magnificent display of railway-engines in an adjoining exhibit any portion of the attention and thought they so well deserved, who considered their steady, upward growth and improvement from the first crudely-designed and roughly-built engines to the splendid specimens of these later days, who recalled what he had heard of the trial of the little "Rocket" at Rainhill long ago, and remembered the jibes and jeers with which the canny Scotsman was greeted when he announced his purpose to make a wagon go by steam, and who then thought of what has since been accomplished through the agency of the locomotive, would dissent from the proposition that among the names of the immortals the name of Stephenson should be written.

It was easy to see, in the improvements shown from year to year in locomotive-building, how there had been given to it the best thoughts and the increased experience of many men. As we look upon what they have now so well accomplished we are prone to forget the early toilers, many of whom lie in unknown and unhonored graves, though they, in the beginning, with no previous experience, with few or no tools to work with, marked out the course and blazed the way in which others, with better opportunities, accomplished what they could only dream of.

Grouped in that great White City was everything from alpha to omega of what the engineer had accomplished in the line of railway-appliances. But while millions of lookers-on passed up and down, gazing with curiosity, interest, or indifference, how few were there who read the story that these mute machines told. Here and there, amid the pressing throng, was some gray-haired man who, casting but a hurried glance at the new and highly-polished locomotives that stood so proudly at the head of the line, pushed down to find, perchance near the beginning, the little old engine which, as he remembered, came to the village wherein he was an idle schoolboy. As he stopped to look with loving eyes on each bar and bolt and wheel and curving pipe, the memory of the old days came back to him as he thought of the then new railroad with its strap-rails and quaint engine and cars, and he remembered that, had the choice then been given him of a kingdom and a throne or a locomotive all his own, the kingdom could have gone to another. Perchance in after years he had himself stood upon the foot-board or in other ways had known what it was to hold in his hand a lever that gave him control over untold forces to let them free or curb them at his will,—and what that feeling is only the chosen few know. But, be that as it may, as he turned away with averted eyes from the little old engine the passers may have wondered what the old man saw in that worn and rusty machine. Had they been wiser and known the memories it had evoked, they would have passed by with uncovered heads.

With the names of Watt and Stephenson, upon the high entablature, were written those of other engineers who in their lifetime had done much to help onward the progress of the age in which they lived, but time and space forbid their mention now. Suffice to say, about each life so spent there are for the pen of the ready writer facts and fancies enough to fill a volume which would read like a romance. If the mere mention of the engineers of the past and present implies so much, who can describe fully all that they have accomplished?

So strange, startling, and rapid have been the exploits of the engineer that the world has lost all sense of surprise, and has ceased to wonder what he will do next. To follow out any one of the numerous lines of work in which he has been engaged, to trace the development of the first crude mechanism he produced up to the splendid triumphs of the present day in almost any department of industry, would be no idle task. Long ago, as history tells us, all Europe was ablaze with the wild enthusiasm engendered by Peter the Hermit, as he summoned the Crusaders to the task of wresting the holy sepulcher from the hands of the infidel. Never before had the world witnessed such an uprising, never before had the pomp and circumstance of war held such high regard in the minds of all. From every mountain-side, from out of the valleys and narrow defiles, the mail-clad warriors came swarming over the plains of Europe to meet together under the walls of the holy city. The story of the conflict there has been told in the legends and songs of all languages. There the Toledo blade of the cavalier flashed in the air to meet the descending scimitar of the turbaned Turk, until, amid the clash of arms, horsemen and horse alike struggled and died in the dire affray, and the streets ran red with blood. Centuries afterwards, when, save here and there, a cloven helmet or a pierced cuirass housed in an ancient museum was all that was left to tell the tale of the slaughtered hosts, the turbaned Turk was still to be seen calmly sitting in the city gate, filling its bazaars, and worshiping in its mosques.

But there arose another Crusader, with his face turned toward the orient and a deep-set purpose in his heart. No Peter with waving torch heralded his coming or lighted his way, no waving banners or blaring trumpets preceded him on his march with a few trusty followers. Armed only with compass, chain, and level, he landed on the eastern shore of the Mediterranean, where, peering through his instruments, he slowly marched over the plains to the foot-hills beyond. Still guided by his star in the east, he entered the narrow defiles through which the pilgrims and travelers had for ages trod. Creeping up along the mountain-side for many weary days and nights, he at last found the looked-for path that led him to his wished-for end. Coming back to the sea he shut himself up in his room, and, on the paper before him, he plotted out his route and planned his campaign. Later on, a band of pioneers armed with pick and shovel also landed, and, following the marks the leader had left behind him, they cut away the mountain-side, filled the valleys, and bridged the ravines and rivers.

Following them came another band of workers, strewing the new-made earthworks with a network of wood and iron that for all time to come was to bind in enduring bonds the lands on which they rested. Their work being done, there was landed on the shore of that eastern sea, and not far distant from the scene where long ago the Trojan horse had worked such wonders, another horse whose wonder-workings have far surpassed the one of Troy.

Planted on the roadway of steel, the iron-horse, after conquering all the western hemisphere, and after slaking his thirst in the waters of the Pacific, turned his front toward that eastern land whence came the human race, winding among the defiles and along the mountain-sides of Judea. Thus the Crusader of our day marched, undaunted and unchecked, until at last, rounding a high promontory and rushing across a bridge of steel, the streets of the holy city were reached, and Jerusalem was won—won over to a progress and civilization that never turns back when once the engineer and his works have found entrance and an abiding-place.

While all who love their kind will be pleased to know that this victory of the nineteenth century was one of brains,—trained to the pursuit, not of war, but of industrial pursuits,—it must please us of this new world most to know that the engine first to climb the rugged heights of Judea, first to waken from their long, despondent silence the streets of this new Jerusalem with its rumble of swiftly-turning wheels and stirring breath, first to fling out into that cloudless sky its steam-white banner of peace and good will to man, was an American-built locomotive, handled by an American-born and -bred engineer. While over and above the engine and its train of cars the flags of many nations, new and old, floated in the breeze, it was the starry banner of the greatest republic the world has ever seen that waved to the fore.

The growing importance of the engineer and of his profession has already reached a point where it may well challenge the attention of the young men of the present who are anxiously looking into the future, in order that they may select a line of endeavor which shall insure not only material prosperity, but an honored place among those who have well served their day and generation. Noting what an extended space in the public prints is awarded to the exploits of the politician, and how lucrative in many ways are the emoluments that come to him, it is not strange that many are tempted to adopt politics as a "profession." Yet, if they stop to consider how uncertain is the source from which the power of the politician is derived, how suddenly political friends may change from enthusiasm to indifference or even open hostility; if they will remember how ephemeral is the fame accorded to the holder of a political office that sooner or later must go to another,—they must hesitate to follow after such a will-o'-the-wisp.

Empires, dynasties, and political parties, with their attendant courtiers and intriguing cabals, rise and fall, and the story of what they have done or left undone soon drifts into the musty records of the past, to be forgotten. But to the men who, by their ingenuity and indomitable will, wrest from nature her hidden secrets, harnessing them to the car of progress and helping humanity onward towards that higher civilization that shall make all the world better, and "all akin," is due, and in good time will be awarded, the honors they have so well earned. Foremost among that to-be-remembered class will be found the engineers of the past and their worthy successors of the present.

ELECTRICITY

Conducted by Franklin L Pope.

IT is by no means easy for a novice,—nor, for that matter, for many presumably well-informed electricians,—to grasp at once all the ins and outs, so to speak, of the polyphase systems of electrical distribution. They have furnished, however, an attractive opportunity for the mathematical electrician to display his talents, and one which he has not been backward in improving. But now comes Mr. Charles P. Steinmetz, who is not only a mathematician of more than ordinary ability but a practical man as well, in the best sense of that word, who says that no two of the advanced mathematical theorists who have had so much to say on the subject agree, either with each other, or with the results of actual practice. Furthermore, he ventures to suggest that one reason for this state of facts may be, perhaps, that many of these writers have never seen, much less constructed, a polyphase motor. He severely criticises, from a practical point of view, the polyphase motors exhibited at the World's Fair, contending that, with one exception, they all manifested the same faults: excessive current upon starting (some being unable to start themselves at all when under load), high self-induction, great difference of phase, and so on, all of which, he contends, are faults which may be eliminated by proper means. He contends that it is possible to construct polyphase motors having all the advantages and few or none of the peculiar disadvantages of direct-current motors, and points out in detail wherein these consist. He contends that synchronous motors should be used in preference to induction motors whenever possible, as they not only are smaller but have a higher efficiency.

AT the recent annual convention of the National Electric Light Association in Washington, an attempt was made to collect trustworthy information as to the amount of coal used in actual practice, in the United States, to produce a given quantity of electricity. The data presented was procured by correspondence, the number of amperes, volts, and hours on each circuit reported being considered in connection with the actual amount of coal consumed during the same period of time, including that used for banking fires. In this way the actual number of watt-hours per pound of coal was arrived at in each case. The results, as might have been expected, varied widely, but the best of them cannot be said to compare very favorably with the results which have been reached in the generation of power for manufacturing purposes. The average of watt-hours per pound of coal was found to be 91.7. The most satisfactory result was that in a large station generating about 8,000,000 watts and running twenty-four hours per day, which gave 208 watt-hours per pound of hard screenings, while the opposite extreme was reached in the case of a station which claimed only 30 watt-hours per pound of soft coal, the output being 30,000 watts and the service seven hours per day. A comparison made between these results and those attained by the engines of a large manufacturing establishment in Brooklyn certainly furnishes food for thought. In the plant last named a load varying from 495 to 765 indicated horse-power, averaging 653.3 horse-power, was maintained with a coal-consumption of 1482 pounds per indicated horse-power per hour. The equipment consisted of Corliss compound-condensing engines and vertical tubular boilers, which were in operation ten hours per day. The fuel used was George's Creek bituminous coal. The efficiency of this plant, therefore, is nearly double that of the best electric plant reported, and about thirteen times that of the worst one.

In a paper read before the National Electric Light Association, the question of the use of the earth as a return-circuit in the electric-railway service was discussed by J. H. Vail, who called attention to some very important facts. Instances have been known, he says, in which as much as 40 per cent. of the total return-current from an electric-railway circuit finds its way back to the central station through the water, gas, and other subterranean metallic-pipe systems. It has been established by careful tests that a current even of no more than five amperes may produce a very considerable electrolytic action upon a pipe in the course of a year, often resulting in material damage. The rapidity of action in any particular case depends upon the character of soil, the amount of moisture, and the quantity of current, but the destructive action in any case is constant and sure. Mr. Vail says that the track-system of all electric railways should be the positive side, or out-going circuit, in order that any arc which occurs between the trolley-wheel and the trolley-wire will carry metal from the wheel and deposit it in the wire. With the reverse arrangement, the strength and conductivity of the wire must ultimately become seriously impaired. The remedy which he proposes for existing difficulties is to bond the track-rails in a thorough manner, so that the conductivity of the joints will be nearly or quite equal to that of the standard rail-section, and to supply the track-system, thus bonded, with insulating feeders and extending directly from the station to predetermined points with an accurately calculated fall of potential. This, he points out, will result in reduced fuel-consumption, better working motors, great reduction in expense of repairs, and increased efficiency of the entire system.

President E. A. Armstrong, in his address before the National Electric Light Association, said that, according to the most trustworthy information available, there were now in this country upwards of 2300 electric central stations, representing an invested capital of at least $200,000,000, and it was estimated that at least an equal amount was invested in the manufacture of electrical machinery and supplies. He had remarked a tendency, especially during the past few months, towards a revival of the agitation for the establishment of municipal electric-light plants, which he had reason to think had been instigated by representatives of some of the large electrical manufacturing corporations.

The measurement of the illuminating power of arc-lamps by ordinary means, with any approximation to accuracy, has long been recognized as a practical impossibility. It is now proposed that a 2000 candle-power arc-lamp shall be understood to be one requiring an average consumption of energy of 450 watts, the measurement being made at the lamp terminals, and with no appreciable resistance in circuit with the arc. It is to be hoped that the definition will be accepted, and this much vexed question finally disposed of.

The most serious difficulty which the electric central-station manager is compelled to contend with, looking at the matter from its commercial side, is the comparatively small number of hours in the year during which his invested capital is productive. Thus if each incandescent lamp in service is kept alight for a period of 1000 hours out of the possible 8766 hours in a year, it is considered to be doing very well. This necessitates what would at first appear to be an exceedingly high rate of charge for the power corresponding to a given amount of light. It has been for some time very apparent to central-station managers that some scheme must be devised, if possible, whereby the consumption of current may be increased during other parts of the day than at the time of the maximum load, viz., from dusk to 10 P. M. In such case a lower average rate could be charged for the illuminating service, and yet the general business and net receipts could at the same time be materially increased. W. S. Hadaway, Jr., in the *Electrical Engineer* (New York), points out that the efficiency of the ordinary cooking-range, as determined by Tyndall, Beaumont, and others, does not exceed 4 per cent., indicating that of every twenty-seven pounds of coal consumed, in that appliance, twenty-six pounds are actually wasted, whereas the efficiency of a well designed electric central station of moderate size may fairly be taken to be about 6 per cent. Hence there would seem to be sufficient margin between a heat efficiency of 4 per cent. and one of 6 per cent. to warrant the use of electricity as a source of heat in culinary operations. Even at the same cost, there are many advantages gained which appeal strongly to the average housekeeper. The saving of time and attendance, the avoidance of heat in the kitchen, and the capacity for accurate control and regulation, to say nothing of absolute emancipation from the nuisance of coal and ashes, are all considerations of no small practical importance. There appears no good reason why the well-to-do classes of the community, who can afford to use electricity for lighting, cannot equally well afford to use it for cooking and laundry-work. The employment of electricity for these branches of domestic work alone, if it should become general, will go a long way toward solving one of the most perplexing problems which puzzles the central-station manager.

A SPECIAL report has been made to the mayor of Brooklyn by the subway commissioners, in reference to the matter of the corrosion of pipes by electrolysis due to stray currents from the conductors of the electric street-railway systems. By way of illustration of the nature and extent of the damage arising from this cause, the report is accompanied by photographs of specimens of pipes and telephone cables which have been removed from different localities in that city. The same trouble has made its appearance in many other cities, notably Boston and Cambridge. Various remedies are suggested, some of which have been tried, while others are only proposed, but it is perhaps true that an effectual cure, other than the radical one of compelling the street-railway companies to completely insulate their conductors from the earth, is yet to be discovered. It is apparent, however, that the effects of electrolysis may be in many cases materially diminished by the employment of certain precautions. The direction of the flow of current in the railway circuits often makes a great difference, as experiment has amply demonstrated. It has been found that the corrosion may go on actively when the difference of potential is less than half a volt. The conclusion of the commissioners is that a very considerable amount of injury is being done to underground wires and cables, and that it is likely to continue until some better method of returning the electric currents to the generator than that now in vogue can be devised and put in practice. But they say that "it is doubtful if the method of final cure for the difficulty has yet passed its experimental stage."

THE question as to whether it is possible to employ a storage-battery with advantage in connection with a direct-current central station is one which Professor Elihu Thomson says is not susceptible of a general answer. Each case must be considered on its own merits, and with careful reference to all the conditions involved. For traction work, he points out that the experience has thus far not resulted favorably to the claims of the storage-battery, from the standpoint either of economy or of technical adaptability, and that this has been true, even where the conditions in respect to grades and other circumstances have been most favorable.

PROFESSOR SHEPARDSON, of the University of Minnesota, communicates to the *Electrical World* (New York) the result of some important investigations made by two of his students in relation to the actual loss of light which takes place from the use of the ordinary arc-lamp globes. Several curves of intensity of light under different conditions are given, which are of much interest. It was found that a mean spherical illumination of 319 candle-power from the bare arc is reduced to 235, 160, and 140, respectively, when clear, ground, and opal glass globes were used, a maximum of some 55 per cent.

According to Edward Weston, the loss in energy which occurs in the switchboards of some of the large electric stations is amazing. He states that he had occasion recently to examine a switchboard carrying a current of 8000 amperes, in which the waste due to badly-fitted joints in the board, and faulty arrangement of the station ammeters, figured up nearly $5000 a year. He mentions a single ammeter which was found to require $89 worth of energy per year to run it.

There seems to be a marked tendency to the development of the arc-lamp in the direction of its application to incandescent circuits. Although many varieties of arc-lamps have been designed for this purpose, which give more or less satisfactory results, most of them are practically of the same type, the difference being mainly one of detail in construction. One great difficulty hitherto has been in the waste of energy due to the necessary introduction of dead resistance, which, under some conditions, may amount to nearly 50 per cent. On the other hand, the actual experience of a company which supplies current for a very large number of arc-lamps, both on the series and low-tension systems, shows that current can be produced for the low-tension lamps at a figure 25 per cent. less than for the high-tension series lamps. The actual result appears to be that, on a large scale, there need be practically but little difference, so far as actual cost of operation is concerned, between the two systems.

Few persons who are not experts appear to have any conception of the enormous losses which sometimes occur in badly-designed and ill-proportioned systems of electrical distribution from central stations. Actual measurements which have been made within the past year on electric-railway plants operating with a station pressure of from 500 to 550 volts, which showed a pressure of not more than 300 to 325 volts at some of the remoter parts of the system, indicating a direct waste of power between the dynamo and the motors of over 40 per cent. of the coal consumed. Such a result indicates the existence of fundamental mistakes in the original planning of the system. Similar errors, though usually less glaring ones, are not uncommon in electric-lighting systems, but in these the effect upon the illumination is usually so patent that there is a much better chance of their being sought out and remedied than in the case of a railway system in which the losses are comparatively unseen.

The electrician of the Chicago Association of Fire Underwriters has recently submitted a report on the causes of fires, from which it appears that, of the seventy-seven fires alleged to have been caused by electricity, there is scarcely a single instance in which the trouble might not have been avoided, either by the use of better material or by the exercise of greater care and discretion in the wiring and fitting. Some of the cases reported, as, for example, that of the attachment of a call-bell to a 50-volt circuit within a building, can only be characterized as instances of inexcusable, if not criminal, negligence.

A recent census of the electric-light and -power industries of France shows that (exclusive of Paris) there are now 301 central stations, aggregating 38,200 horse-power, of which 21,820 is steam, 9259 water, and 6000 steam and water combined, the remaining power being furnished by gas. Water-power is used in the greater number of stations, there being 136 of these as against 113 operated by steam. The relative proportion of alternating- and direct-current stations is in curious contrast to the conditions prevailing in this country, there being no less than 248 of the former to 47 of the latter. Many of the more important stations now under construction in France will employ the polyphase system of distribution, and will use gas-engines for motive-power.

THE adoption of municipal ordinances regulating the maximum speed of electric street-cars has developed the necessity of applying to each car some automatic device which shall notify the employés and the traveling public whenever the prescribed limit is being exceeded. A recent contrivance for this purpose consists of a centrifugal device attached to one of the car-axles, which, by means of a connection which is adjustable to suit any required speed, is made to sound a bell at each revolution of the axle until the speed has been reduced to its proper rate.

THE solicitude which for some time has prevailed in certain quarters in reference to the application of electricity to the propulsion of boats on the Erie canal turns out, as might have been expected, to be of a not wholly disinterested character. A corporation with which a number of prominent citizens are associated has been granted a permit for fifty years, authorizing it to enter upon all the canal lands of the state for the purpose of erecting and maintaining a plant for the distribution of electricity for heat, light, and power in the cities and towns along the line of the canals, in consideration of which the company is to furnish the state with electric power for operating the lock-gates, and for the illumination of the locks at night. Electric power is to be furnished to private boat-owners, at a rate of charge not exceeding $20 per horse-power during the season of navigation. The state reserves the right to purchase the canal towage or traction plant at any time hereafter, at an advance to 10 per cent. upon its original cost. The corporation to which these privileges have been granted appears to be one of the subsidiary organizations of the Niagara Power Company, and it is of course the intention to obtain electrical power from Niagara Falls, and to dispose of it in the numerous thriving cities and towns along the line of the canal between Buffalo and Albany. The enormous value of a clear right of way for the distributing conductors, such as that afforded by the route of the canal, is apparent. The maximum of charge to the boat-owners cannot be said to be at all unreasonable, though it is undoubtedly enough to afford a satisfactory margin of profit to the supply-company. It is comparatively a matter of small consequence to the company whether the boatmen avail themselves of the opportunity to use electric power or not; the main thing is the securing of the right of way for supplying electricity to the cities of central New York. It is not unlikely, however, that the use of electricity on the canal may become sufficiently general to demonstrate the advisability of enlarging its capacity to enable it to more nearly meet the demands of modern commerce.

ONE of the fundamental errors made in the electric-lighting business at the outset was that of charging the consumers at a contract price per lamp per year, although, from the lack of a suitable meter, this was at the time to a large extent unavoidable. One company undertook to furnish its customers with a lamp in place of every gas-jet removed, basing the rate of charge upon the gas-bills of the preceding year, and afterwards found, upon applying meters to the service, that it had been getting paid for only 32 per cent. of the gross output. Another case reported is that of a hotel which was being supplied at a flat rate of $175 per month, which, when metered and charged for at the regular rate, amounted to no less than $1100. Some companies which have adopted the meter system have been able to cut down their output one-half and at the same time increase their revenue. There is nothing bought or sold which does not represent energy, and there is no equitable way of buying or selling energy except by weight and measure.

IT is a fact, which has long been patent to those well versed in the history of electric telegraphy, that the essential features of the system now in almost universal use throughout the world embody little or nothing of the original inventions of Professor Morse, although the American system of telegraphy always has been, and probably always will be, inseparably associated with his name. In its essential principles, and even in its structural features, the telegraph, in its modern form, is in essence nothing more than the electro-magnetic signalling apparatus of Joseph Henry, constructed and exhibited by him at the Albany Academy in 1831, to which has been applied the mode of operation and conventional alphabetical code devised by Alfred Vail in 1837. The contribution of Morse to the ultimate result has not inaptly been likened to the false work of an arch, which has not only given its form and organization to the structure, but without which its very existence would have been impossible, and yet which forms no necessary or even desirable part of the complete whole. A series of papers now in course of publication by Miss Henry in the *Electrical Engineer* gives a circumstantial and interesting account of the mental and physical processes by which her honored father was led, step by step, to one of the most important—if not the most important, when measured by the vastness of its effects—discoveries of the nineteenth century: that of the fundamental principle underlying the construction of the electro-magnet, and its relations to the source of electricity from whence its energy is derived. Much of the matter given by Miss Henry is from original documents, and now appears in print for the first time. It seems eminently fitting that this work should be given to the world by the favorite daughter, who not only shared in, but as her writings show, thoroughly understood and appreciated, the labors of the most eminent of American philosophers.

DURING the past summer the West End Railway Co. of Boston made quite an extensive experiment in the way of electrically welding the rails of its tracks, of which some mention was made in these notes at the time. It now appears that about 10 per cent. of these welded rails have broken in service. The experiment seems at least to have established the fact that the alignment of the rails, either vertically or laterally, is not affected by the expansion and contraction,—a contingency respecting which some apprehension had been felt,—but it is yet to be determined whether the contraction has been the real cause of the breakage referred to. It is understood that the experiments are to be continued, but that, hereafter, the entire abutting surfaces of the rails are to be united, and unusual care is to be taken not to injure the fiber of the metal or to restrain the expansion due to the heat. It certainly is to be hoped that the method may prove practically successful, as the continuous rail very perceptibly increases the smooth running of the cars and must materially lengthen the duration of the rolling-stock used on the line.

THE suggestion has been made by Professor Elihu Thomson that the temporary stars which have occasionally been observed to blaze out with great brilliancy and afterwards to fade away may be explained on an electrical hypothesis,—that charged bodies possessing a difference of potential, upon approaching each other, might exchange electricity upon a grand scale, making a display which would continue but for a short time.

IN spite of the outcry made by the newspapers about the dangers accompanying the use of the "deadly trolley," statistics show that the number of casualties is by no means excessive in proportion to the work done. The West End railroad, running in the crowded and crooked thoroughfares of Boston, reported last year only one person killed or injured to every 56,575 miles run. If it were possible to restrain the poorer classes of the community from permitting their small children to make a play-ground of the public streets, the fatalities, few as they are, would be notably diminished. One of the most fruitful causes of accidents is due to the practice of such children of catching surreptitious rides upon the rear steps of cars and suddenly jumping off, when confronted by the conductor, just in time to fall under the wheels of a car going in the opposite direction, a species of accident which no possible caution on the part of the motorman is of any avail to prevent.

ARCHITECTURE

Conducted by Barr Ferree.

THE architectural education of the American architect is one of the most serious and important of professional questions. In no other country are building operations, by builder and by architect, conducted on so large a scale as in the United States, and in no other country, it is but simple truth to tell, have the architects so rapidly come to control such vast and important enterprises. The great buildings of America exceed in size and in cost the great buildings erected by modern European architects. The American structures may be less important in function, and less monumental in aspect, but the money considerations involved are often much larger than is the case in modern European structures, save in occasional instances. Further, the position of the American architect, as regards himself, his profession, and the public, has changed very much in the last few years. It is true that we have not yet reached a point at which incompetent architects are no longer able to make a living in their profession, but that is simply because the greater part of the building population is not yet able to realize what a competent architect is. That is something for the profession as a body to teach the public. Meanwhile, their importance to the public is constantly increasing, and it is becoming of more and more vital importance that the architect should be possessed of the knowledge and skill necessary to perform his manifold duties. The architect's education is, therefore, one of the burning professional questions of the day. Some aspects of this question have been treated already in these pages, but there is begun in this number of the Magazine a symposium on "Architectural Education for Americans," the importance of which we do not think we exaggerate when we describe it as the most important contribution yet made on this topic. Never before have the advocates of the chief systems of architectural education met in converse with each other; and while the papers are independent, not argumentative, each presenting the merits or demerits of the particular system the writer represents, their union, in the brief series here begun, gives them a fresh and important interest they could not have were they scattered among separate publications. Mr. Rotch, who presents the claim of the École des Beaux-Arts, has studied at the famous school and won a name for himself as one of its most distinguished advocates. Mr. Andrews, who argues for a more utilitarian and practical system of architectural education than has yet been put into practice in this country, was trained solely in an architect's office, and his words are, therefore, the weightier on that account. Mr. Robert W. Gibson, who, in the succeeding number of the Magazine, will take up the English system, is one of the most brilliant graduates in this country of a system we know too little about. The series will be concluded by a brief paper by the present writer, presenting "An Outsider's View."

An article in *The Century Magazine* for March, on the Madison Square Garden, might appropriately have been styled "The Apotheosis of Faddism." Never, surely, has the faddic critic risen to greater heights. Yet what more can be expected of a writer who speaks of the "dearest architectural possessions" of New Yorkers? It would be most interesting to know where these possessions are kept; clearly not in New York itself, for, if all the great metropolis were to be swept off into its encircling waters, what loss would there be to art, what hindrance to progress, what would be ruined that could ill be spared?

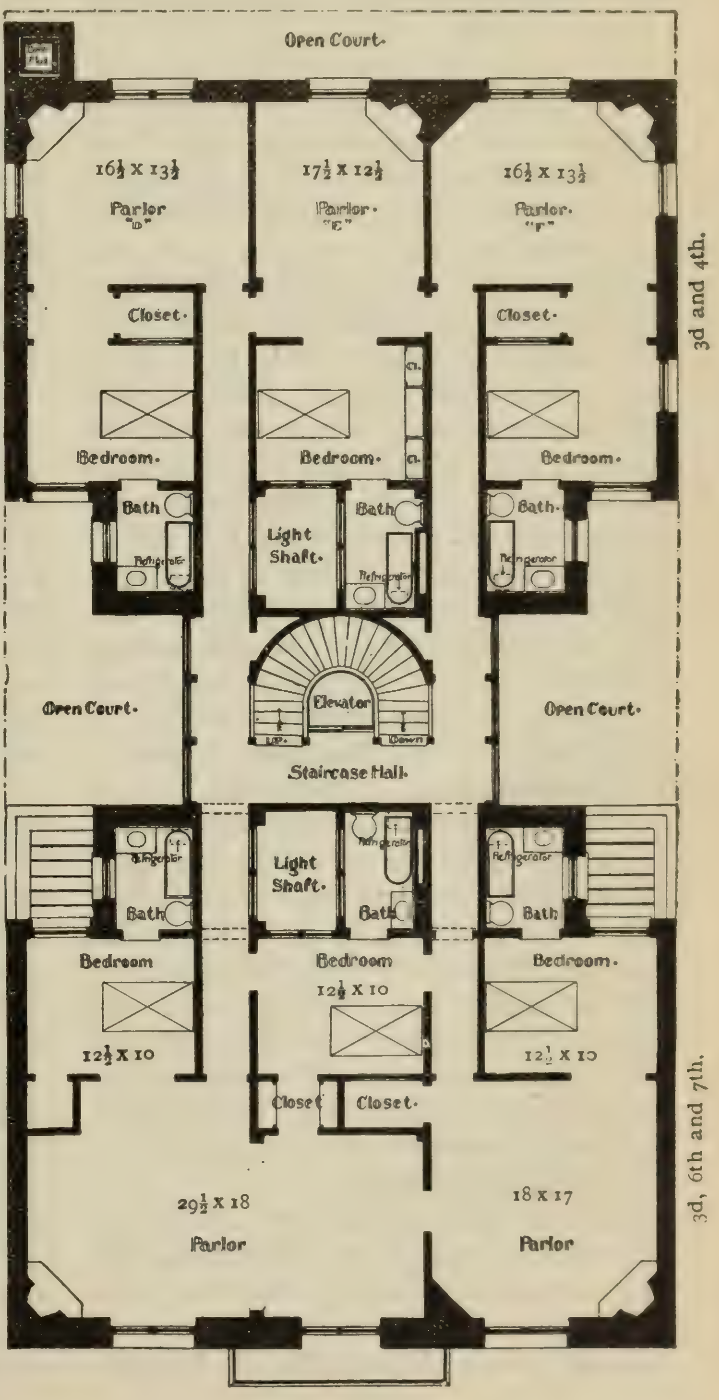
The most reasonable argument against the advantages of such a catastrophe would be that, in the event of its occurring, the most conspicuously bad architect in the city would succeed in reaching the loftiest piece of débris and would be saved, to begin again the construction of monstrosities that too frequently in the past have been considered, within New York's most cultured circle, types of very high architecture. Of course the Madison Square Garden cannot be described in such rough language, yet we do not hesitate to say that the article referred to will speedily be ranked among the curiosities of architectural criticism, if, indeed, so sonorous a title should be applied to an article which seems to be a cross between an advertisement for the architects,—for quite a list of their "jobs" are printed in it, with hints at others,—or for the Garden itself as a place for amusement. One experiences something of a shock in coming across a sentence like this in a sober architectural discussion: "There can hardly be a better place for a big circus than this." Yet with all the faddist's enthusiasm for her subject (and why will the authoress continually refer to herself as "him"?) the writer is unable to close her eyes to certain very obvious faults in the subject supposed to be under review while others she passes over on the plea of ignorance. Why then, if incompetent, write on the subject at all? The article is divided into five sections, or chapters, only two of which are directly concerned with setting forth the faddic conception of beauty and art in the building. We are sorry we have not room to reproduce the paragraph on "a partner whose name the public seldom speaks." It is quite the funniest thing in architectural literature we have seen for many a day. It may be ladylike; it is certainly not gentlemanly.

READERS of certain public organs, affiliated with a certain famous political party, have long been familiar with the remark that "put the———party into power, and you may be certain it will discredit itself." Whether this is true as regards politics we should not like to affirm, but very much the same thing can be said of the editors of the so-called "big" magazines, when they undertake to publish an architectural article and seek to adorn it with pictures. The article itself may be right enough, but the cloven hoof is always visible in the illustrations. Look, for example, if you please, at the picture of the center of the Madison-avenue façade of the Madison Square Garden, in *The Century* for March. That particular centerpiece always seemed to us somewhat pitched on without relation the rest of the building, but it certainly is too bad to print an article whose chief and only end is the exaltation of that building among the works of mankind, and then deface it with such a caricature as this. But if *The Century* is bad, *Scribner's* is worse. It was in this magazine, it will be remembered, that the editor of a comic weekly announced to an awe-stricken world that the arch of the main doorway of the Transportation building at the World's Columbian Exposition was Roman,—an archæological discovery, by the way, that has never received the attention it has deserved, though we have tried to do our part in making it known. Well; almost anything might be looked for in a periodical that would print such talk as that but some of the pictures that accompany the article on "The High Building and Its Art" in its March number are among the most extraordinary that have appeared anywhere. There is a very fine and realistic snow-scene in Boston, with what purports to be the Ames building in the background, and looking so cold and ugly and forbidding that the eye naturally travels to the snow-covered State House in the foreground. This is well matched by a view of the stairs leading to Brooklyn bridge at the City Hall Park, New York, though the picture is not so labelled. The Schiller Theater, which the unfortunate author who was the occasion of these phantasies being given to the world (though not the cause) speaks of as "one of the most beautiful and impressive high buildings in the world," is shown in a view that makes his words a mockery. Nor is this all. The chief point of the article is the insistence on the vertical as the leading element in vertical design. Yet in three illustrations that should bring out this point—the Union Trust building (St. Louis), the Mills building (San Francisco), and the Havemeyer building (New York)—the vertical lines are omitted or repressed, and only the horizontal lines inserted! As the old schoolmaster recently remarked, in the aforesaid comic paper with the editor of an archæological turn of mind, *Umpery trumpery dixum digit sockdologus.*

Did you ever see a building afflicted with the smallpox? If not, it is well worth a journey to Union square, New York, to see such an amazing spectacle. It is not to be supposed that the obtaining of such an effect was the intention of the architect, since the owners of the building have issued numerous circulars calling attention to the attractive quarters that may be found there (for a consideration). And of course it is not criticism to begin the description of a building by making so offensive a comparison, yet this is exactly the effect the author of the Decker building has obtained by the use of bricks, supposedly ornamental in pattern, that are disposed in a symmetrical manner upon the façade; and having obtained this result, why not say so? The lot is only thirty feet wide, and an eleven-story building has been erected upon it. This height is in itself more than ample for a building on a lot of this size, a fact which must be obvious to every one save the maker of the design, who has stretched it out at the top by means of an absurd tower that is rendered more absurd by the hipped roof pinned on on either side of it. The upper part of the building, unfortunately the most conspicuous portion, is utterly barren in artistic treatment, and succeeds only in telling how little the man who made it knew what he was about. This is not unimportant in itself, but it is a pity the information had to be given in so permanent and visible a form. It is, perhaps, scarcely fair to begin with the top of a building, though where it is so wonderful as in this instance any starting-point might be forgiven. Of the base itself nothing need be said. It is a simple store-opening supporting a huge window in a highly-ornamented frame, that stretches across the whole front and needlessly accentuates the opening at the base of the design. The superstructure, if the main portion of the building immediately over this may be so called, is plain enough in its first form, but a simple front did not seem to meet the requirements. Four balconies, arranged in the form of a Maltese cross, have quite needlessly been put up on the front, to the most unfair disadvantage of the tenants not provided with these adjuncts. Two-story windows are introduced into the middle of the design without any connection with each other or the rest of it, affording a most charming diversity where, of all places, it was least needed, and yet having a sort of mellow feeling that prepares one for the festive elements with which the building is finished. It is not the least of the misfortunes of this building that it is the very much the highest structure in the block in which it stands. The raising of the other buildings will not improve it, though it will lessen its aggressiveness. Fortunately the cable cars go pretty fast here.

Professor A. D. F. Hamlin, the accomplished adjunct professor of architecture in Columbia College, announces a four months' tour in Italy for students, for a serious and systematic study of the Italian Renaissance. While there is not the slightest necessity for transferring the work of the Italian Renaissance to this country, such a course of study as is proposed by Professor Hamlin will unquestionably be of the utmost advantage to those who avail themselves of the rare opportunity this tour offers. Professor Hamlin is not only an accomplished teacher of architecture, but a profound and brilliant scholar, and those who place themselves under his guidance will have the satisfaction of traveling and studying under the leadership of a most accomplished cicerone, with the added pleasure of a sympathetic master, amply versed in the subject he is teaching. Many architectural tours have been proposed, from time to time, but we know of none that promises better results, or is based on a more excellent idea, than that Professor Hamlin has put forth. The study of any style in the class-room is a very different thing from its study in the monuments themselves, and when to this obvious advantage is added the instruction of a master the opportunity becomes one of a lifetime. The class will meet in Naples early in June and follow a carefully-prepared itinerary, though we understand this may be modified with the consent of the majority of the students. It is an altogether new feature in architectural education in this country, and it needs no prophetic vision to foretell most striking and notable results therefrom. Preliminary "public talks" on the route and monuments to be studied will shortly begin in New York, so that the utmost amount of preliminary work may be done before the journey is begun. Those who are able to take advantage of this plan may well be envied for the extraordinary advantages they will enjoy, and we trust that Professor Hamlin will secure a large and appreciative class. He can hardly escape an enthusiastic one if he can communicate a tithe of his own enthusiasm to his men. We recommend that architectural students—and this should not include very young men alone—who are contemplating a European jaunt this summer place themselves in immeiate communication with Professor Hamlin, who may be addressed at Columbia College, New York, and all who approach him may, we are sure, confidently count on a hearty and generous response.

MESSRS. CARRERE & HASTINGS have produced a very clever plan for their *Life* building in New York. This is an eight-story structure intended for bachelor apartments and studios, the lower floors being devoted to business. Clever as the plan is, it is simply a modification and adaptation of a plan already much in use in New York and elsewhere for tenements and dwellings. The floor-space is divided, by two courts opened into the center of each side, into a front and back building. These open courts light the rear rooms of both front and back buildings, on which are placed the sleeping- and bath-rooms belonging to the corner suites of apartments, as well as the middle of the building block, in which are placed the stairway and elevator. As an additional court is placed on the rear of the building, it follows that

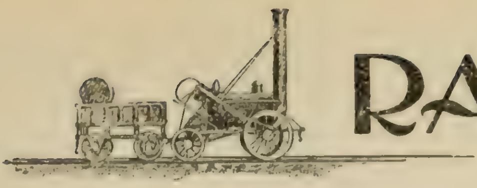


PLAN OF THIRD FLOOR, "LIFE" BUILDING, NEW YORK.

the parlors, bedrooms, and bath-rooms are all amply lighted. Two small light wells are introduced into the center of the building which light the bedrooms and bath-rooms of the middle suites of rooms, both front and rear, as well as the adjacent corridor. Throughout the building the utmost pains have been taken to secure the maximum of light and air at the cost of a minimum of floor-space. The typical floor-plan shows great simplicity of arrangement and wise use of space, and the whole gives evidence of most careful and judicious study.

PHILADELPHIA is one of the most delightful cities in the world to visit. It is especially so in times of mental depression and worry, for the good town itself is so depressed by nature, and is so calm and peaceful withal, that one positively relishes meeting with an atmosphere below one's own, while enjoying the vacuity of space that cannot be had in busier towns. Philadelphia architecture is also, as all the world knows, a sight worth many a day's journey to see, and it is altogether possible to enjoy a brief sojourn in what is one of the most singular and striking of American municipalities. Yet, strange as Philadelphia architecture is, it is most strange that there has recently grown up, among the sordid and preposterous structures for which that city has long been famous, a really notable school of architects who are producing some of the most artistic and satisfying architecture within the geographical and political limits of the United States of America. In other words, the unexpected and unforeseen has happened, and an architectural Renaissance, of extended proportions, of interesting variety and of very charming results, has made its appearance in Philadelphia. Long may its beneficent influence be felt, and may its shadow never grow less!

The most notable work produced by the Philadelphia school of architects,—for their importance is such that they may justly be so styled,—has been done by Messrs. Frank Miles Day & Brother, Wilson Eyre, and Cope & Stewardson Some others are following in the paths these pioneers of the artistic in Philadelphia have opened up, for, though the good influence of these four men has been slow, it has been steady and will grow and increase from year to year. The prevailing note in their work is its fine artistic feeling. It is not always great,—indeed, it would be unjust to speak of them as great architects in the fullest sense of the word,—but it is good, and seeks generally to obtain its results by form and proportion rather than by ornament and elaboration. That such a school should rise up in Philadelphia is the most healthy sign of the decay of barbarism in this country we have met with in many a day. Mr. Day's ornament is sometimes too small in scale for the building on which it is placed; Mr. Eyre does not always escape from an affectation of form and of grouping; and Messrs. Cope & Stewardson sometimes err a little in both directions; but the work of each is very good in itself,—quite the best that is done in Philadelphia and decidedly better, as a whole, than much of the work done in more enlightened communities. It is work that is not only pleasing and satisfying in itself, but that repays careful study, and has formed the basis of other work by other men in Philadelphia and elsewhere. We repeat: the work of this quartette of Philadelphia architects is entitled to rank among the best done in this country, and we congratulate Philadelphia in being able to afford a sufficiently-remunerative practice to keep men of such marked ability at home. Each day brings increased appreciation of the value of their work, and each day is hastening the time when the architecture of Philadelphia will cease to be a reproach to intelligent men. The progress of the architectural Renaissance in Philadelphia has been most interesting and satisfactory, and its future history promises, under such accomplished leadership, to be among the most brilliant revivals of the art we have had in this country.



RAILWAYS

Conducted by Thomas L. Greene.

THE *Financial Chronicle* publishes statements for the calendar year 1893 of the gross and net earnings of 198 railways, having an aggregate length of 117,000 miles. The statement therefore comprises about two-thirds of our railway mileage. The railways last year did a fairly good business for about five months. During the summer and fall the freight traffic fell off very heavily, the decreases being offset to a great extent by the largely-increased passenger receipts owing to the World's Fair. The result of the combination of these good and bad elements shows but a trifling change over 1892 ; the gross earnings exhibiting a decrease of 1.6 per cent., the operating expenses 0.9 per cent., and the net earnings a falling-off of 3.4 per cent. These percentages do not set forth the present situation fairly, the latter months of 1893 and the opening months of the new year making a much worse showing than the other months. The railways whose fiscal year ends on June 30 will not have so favorable an exhibit to make. Meanwhile, however, it is pleasant to know that the results of the calendar year are, comparatively, so good.

There is now no doubt that but for the World's Fair travel the railways would have shown very different results for 1893. This can clearly be seen from the annual reports already made public. The Chicago and Alton, for example, reports a continuous decline in freight traffic since 1887, the year in which so many railways in its territory extended their lines ; a policy which that company did not follow. As to the passenger traffic, however, while the number of local passengers was slightly less than in 1892, the number of through passengers increased nearly one-third, so that the total number of passengers carried one mile was greater by 20 per cent. than in 1892, while the number of train-miles was a trifle less. As a consequence, the average earnings per passenger train-mile increased from $1.21 to $1.46 in 1893, a gain which is to be ascribed almost wholly to the Chicago travel. The passenger gains from the World's Fair were large enough on the Chicago and Alton to offset the losses in freight traffic, so that the company was able to report net earnings of the same amount as in the previous year. What is here said in detail of the Chicago and Alton is true of all the railways centering in Chicago.

THE report of the Pennsylvania railroad, one of the greatest systems in the United States, has been widely published. The figures dealt with are too large to admit of close analysis. The point of most interest in the report is that the income of the railroad from outside investments is larger than the interest on the funded debt, a showing which no other company is able to make. The Pennsylvania, from year to year, bought the stocks and bonds of roads which could profitably be joined to its system and swell its traffic. It rarely happens that these auxiliary lines show a profit from their own working; their benefit to the parent railway is usually indirect. A year or more ago, when the then Reading managers were attacking the Pennsylvania, it was alleged in pamphlets circulated both here and abroad that this outside income of the Pennsylvania was not accurately stated, and that some of the subordinate companies did not really earn the money credited to them in the Pennsylvania report. Detailed information is not available for proving or disproving this statement made in controversy. There seems no reason to doubt, however, that the legitimate income of the Pennsylvania railroad from self-sustaining parts of its system is enough to contribute materially to the dividends paid. It is also to be noted as an element of strength that the

Pennsylvania railroad spends from its earnings upwards of $2,000,000 each year in betterments not charged to capital account.

In contrast to the strong position of the Pennsylvania railroad must be noted a number of other companies in the United State, whose requirements for bond interest each year are so close to their earnings that in a period of depression the safety of the companies is impaired, while every possible expense, whether necessary or not, is cut down. The *Railroad Gazette* has compiled a table giving the amounts owed, first for expenses and then for all prior charges before dividends, out of each $100 of gross and net earnings for eleven representative companies:

	Of gross earnings.	Of net earnings.
Boston & Albany............	$80.05	$16.17
Chicago & Northwestern	85.39	57.27
Chicago, Burlington & Quincy..	85.45	59.30
Chicago, Milwaukee & St. Paul.	86.70	61.00
New York Central & Hud. Riv.	89.86	67.97
Louisville & Nashville........	88.74	70.10
Atchison, Topeka & Santa Fé..	95.36	85.83
Union Pacific........	95.20	87.46
New York, Lake Erie & West'n	96.98	91.32
Philadelphia & Reading.......	96.31	91.45
Northern Pacific.............	103.72	107.97

The five last-named companies are now in the hands of receivers, their margin of safety having been exhausted. We touch here upon the besetting sin of American corporation finance. Railway-owners in the past have capitalized their expectations, so that, when legitimate expenses increase or traffic falls off, a receivership is inevitable. No railway company should willingly be bonded or stocked to such amounts as would bring disaster in dull times. If railway financiering were more conservative and healthful there would be a margin, even in periods of depression, which could be spent for the needed repairs and supplies.

The year 1893 was the first since the civil war when the increase of railway mileage was comparatively less than the increase in population. This simple statement is at once an evidence of our business depression, and also a good ground for hope that the stagnation in the building and maintenance of railways is temporary. It is significant of the possibilities of the future to know that while Massachusetts has 26 miles of railway for every 100 square miles of territory, Pennsylvania 20, and Ohio 26, the younger states of Nebraska and Minnesota have but 7, Kansas 11, North Dakota and California 3, and Georgia 8, while the Mississippi-valley states occupy an intermediate position between these extremes. As immigration fills up the population of our newer states we may reasonably anticipate that the number of miles of railway in those states will in time approximate to the proportion in the more thickly-settled eastern states—that is, will be increased one-half, as population increases to warrant the additional construction.

The contract given to the Hall Signal Co. for the putting in of their system of block signals on the Delaware, Lackawanna, and Western railroad has given rise to some discussion regarding the relative merits of various kinds of apparatus. It is not possible or necessary in these columns to enter into a long examination of the whole question, but a word or two may be said in reference to the particular case at issue. The New York Central is a good type of the railroads which have an excellent block-signal system operated by hand. That company has guarded against the possibility of mistakes on the part of operators as much as possible by using the Sykes interlocking apparatus, which requires the consent of two operators before trains are admitted to the block. There are certain advantages in such a system which all must admit. The objection on the part of the railroad-men is not to the original cost of the apparatus, nor to its reliability, but to the addition which it requires to the operating expenses of the road. The tower-men must be paid, say $40 per month on the average, and, although in the country the blocks can be made long, it can easily be seen that the increase in the annual expense is an important item. The reason for the success of the automatic methods is because these do away with the employment of so many men: thus the Pennsylvania railroad out of New York city is using an automatic signal, moved by compressed air and controlled by electricity, put in by the Union Switch and Signal Co. Iron bridges are put across the track above the trains, on which are semaphores indicating by position whether the block is free. The power necessary to move these arms, particularly during storms of wind or sleet, requires an apparatus of some strength and cost. Moreover, such an automatic system needs constant and careful inspection. This inspection is almost as expensive as the wages of tower-men would be, especially as the system is yet in its infancy, so that the annual cost of operating the system has not yet been reduced low enough to satisfy the majority of the railways.

THE principle of the Hall system is practically the same as that in use on the Pennsylvania railroad, with the exception that, instead of moving the signals by pneumatic power, the Hall company rely exclusively on electricity, the current being conveyed through the track. The objections which heretofore have been urged against systems operated through track current, the Hall company believe, have been removed in their case by the use of the best materials and workmanship; but electric power is not strong enough to operate the comparatively heavy signal-arms used on the Pennslyvania railroad. If electricity, therefore, is to be used as automatic power, some lighter form for the signal proper must be devised. The Hall company meet this difficulty by using boxes with a round face at the top, like an old-fashioned clock, covered with glass; inside this box a disk is displayed which can be seen through the glass easily by an observer at a moderate distance. Not a few railroad-men think that a system of signals to be really useful should be of such a character as to be seen by the engine-driver from a long interval, and which could not become obscured, say by a storm of sleet. To those who hold firmly to this opinion the Hall system of signals may seem objectionable. On the other hand, other railroad-men say that a signal which can be seen within 200 or 300 yards is all that is really required, and is all that the best signals can offer in a fog or a storm,—the very time when they are needed the most. Such men make no objection to the Hall system of displaying signals through a glass box, except as to the possible obscuring of the signal by adhering snow or sleet. The advantage of the system of operating signals by electricity alone is, or ought to be, the comparative cheapness of the apparatus, for the cost ought to be much less than any system using compressed air. Railroad companies which prefer to use an automatic system of block-signals must take their choice between the more expensive apparatus which uses signals easily seen from a distance, and the cheaper form which is subject to the limitations already mentioned.

THE important question of the duties of railroad employés to the public has received renewed attention under the orders issued at Milwaukee and Omaha forbidding employés on the Northern and Union Pacific railways to strike. The receivers of these roads reduced the wages of their men and then obtained an order from the court prohibiting the employés or their trade-unions from conspiring or agreeing together to quit the service. These orders have stirred up a great deal of indignation among the laboring classes and their friends both in and out of congress, and the actions of Judges Jenkins and Dundy have been severely criticised. If we consider the strike matter separate from the question of wages, it is well to say that all good corporation lawyers are agreed in thinking the principle of these court orders to be correct. When railways are operated by the court, of course the court is directly responsible for the continuance of the service to the public. The fact of the receivership brings this truth directly to the attention of the judge. Whether wages are too high or too low is a question which ought to be settled in some other way than by a stoppage of trains. When brakemen or switchmen accept service on a railway they take their positions under an implied agreement to respect the rights of the traveling and shipping public. Of course these employés are free men and have a legal right to leave the service of the company whenever they choose, but it is more than doubtful whether they have a right to combine with their fellow-employés so that all should quit their positions at once and leave the railway unable to run its trains.

It is very likely true that the orders of these judges were too broad, and covered, by implication at least, more than was really intended. It is also a grave question whether it was just for these courts to declare a reduction of wages on the recommendation of the receivers, without hearing evidence to the contrary from the employés themselves. Indeed, the courts of the several districts through which the Union Pacific runs have already fallen foul of each other on this very point. The whole controversy, however, may turn out to be of great importance as pointing out the way toward a settlement of the perplexing labor problem. On the one hand it is quite possible that the precedent of the Ann Arbor case, followed by these later cases, will result in the adoption of a definite policy by the courts to the effect that strikes ordered through combinations of laboring men are illegal, if they have for their object the stoppage of trains, whose continued movement the judges are coming to believe it is their public duty to enforce. On the other hand, the same trade-unions have a right to go before the same courts and oppose a reduction in wages or advocate an advance. Thus the question of the proper scale of wages may receive some judicial interpretation.

PROFESSOR RICHARD T. ELY, of the University of Wisconsin, is an entertaining writer whose articles appear from time to time in our popular magazines. Professor Ely is a pronounced socialist in the sense that he believes it would be better if nearly all of our large industries were in the hands of the state. His critics assert that his theories are not well reasoned out, and that he neglects to consider some important and even elementary facts bearing upon his position. His favorite idea, to which he returns again and again, seems to be that the railways of the country ought to be owned and managed by the government; but in this scheme of nationalization Professor Ely omits to discuss the question of ways and means. It is true that the credit of the government is good, and that it could borrow money for the purchase of our railways at 3 per cent., but the debt which it would incur in such an enterprise would be as great as that caused by the civil war. If railway employés now strike against reductions of pay or for increases, it may be set down as certain that their demands for large salaries and wages would be most pressing if the government were their employer. In fact, an increase in all expenses would be inevitable. Meanwhile the farmers, whose wheat is not bringing cost at the farm, and all other producers the value of whose products depends to an important extent upon the cost of transportation, would clamor for lower railway charges, and in the end would be certain to get what they want. If many of our important railways are now close to the margin of safety it does not require a prophetic mind to see what the result of the workings of these two opposing forces would be under government ownership. The revenues would decrease and the expenses would advance until they met or even crossed each other, and before long not a dollar would be earned on the enormous government debt put out to purchase the transportation lines. The annual interest would have to be paid, and would be raised by general taxation. Every American reader of this Magazine would have to pay his share of these taxes, whether he used the railway or not. The present system, with all its faults, is more equitable, at least in this one respect, that those who travel or ship goods pay for the privilege, and cannot ask the non-traveling or non-shipping public to bear their burden for them.

MINING AND METALLURGY

Conducted by Albert Williams, Jr.

AS showing not only the pressure of hard times upon iron-ore mining, as in all other industries, but also the remarkably close shaving now necessary and which presumably still admits of a profit a contract just announced is noteworthy, It is for 90,000 tons of Bessemer ore from the Norrie mines on the Gogebic range, to be delivered at $2.75 per ton at South Chicago. This ore, after standing the expense of mining and royalty, has to be carried by rail about forty miles to Ashland, the shipping-point, thence by lake to destination, with additional costs for insurance, commissions, and incidentals. The rate is said, by the *Engineering and Mining Journal*, which gives an analysis of the items, to be nearly a dollar lower than was thought possible last season. The actual cost of bringing the ore to the surface (that is, for all mining costs) is stated on good authority to be not less than 65 cents a ton, a figure which evidently cannot be much cut down. Taking former freight-rates, etc., as basis, only 20 cents a ton would be left to cover interest on mining capital and all other charges, which, as the *Journal* says, is "entirely too narrow for comfort." Evidently some very close figuring all around has been done.

ONE consideration is frequently overlooked in figuring what a mine can stand in the way of low prices for its product, and that is that the mine is not inexhaustible. A mine is not like a farm, which, under prudent management and with proper fertilizing, can go on indefinitely yielding its crops year after year; nor yet like a factory, which with due allowance for repairs and depreciation of plant, has only to meet one year's demands at a time. Every ton taken out of the ground is an absolute diminution of resources by just that one ton. There were so many tons there originally, no matter how vast the deposit; and there is no way of replenishing the stock started with. Now the money invested is to be repaid by that which comes out of the mine, and this output must not only pay interest on the investment, and that too at a pretty high rate, to allow for the mining risk, but it must also act as a sinking-fund; so that, when all the ore is finally exhausted, as sooner or later it inevitably must be, the sinking-fund shall have extinguished the original outlay. The life of a mine, however long, is a finite quantity; and, under modern conditions of pushing the capacity to the utmost, the time is steadily lessening. Yet mine-operators seem to overlook this vital factor in their enterprises and go on basing their calculations upon a never-ceasing output. It is not a case of killing the goose that lays the golden eggs, yet there is something somewhat similar in such a policy. Of course this line of reasoning is in a sense theoretical merely, and it must be admitted that managers who have to meet the stress of sharp competition must do the best they can and submit to sacrifices if they would keep their mines going at all. But it is none the less a point worthy of serious thought. And yet was there ever a mining report (barring the preliminary surveys, with their "ore in sight" estimates) that, in presenting a balance-sheet, made any allowance for diminution of resources?

IN some kinds of mining it is possible to estimate in advance about how long the deposit will last, at a given rate of extraction. This is true of regular and well-surveyed coal-beds, for example. It is true also, in less degree, of placer mines, where the area and depth of the deposit are known. It does not hold with most metalliferous mines, whose ore-bodies are irregular and more or less pockety. When a coal-mining enterprise is set on foot it is customary to figure out so much available coal per acre, and so much acreage to be mined in a given time; yet, after mining is actually begun, the preliminary calculation (on which the investment was based) is lost sight of entirely. If such is the case where the best opportunity exists for prudent prevision, how much the more careless in those cases where the exact extent of the deposits cannot be foreknown.

DIVERSE views as to the operation of the patent system of ownership of mining claims have been brought out in a discussion between some western papers. One or two have claimed that the system is working injury to the interests of the country insomuch as some of the owners of prospects that have been patented refuse to work them themselves and will not sell except at rates that are practically prohibitive. That is, that there are those who hold mining ground on speculation, hoping to make a big deal by selling to some eastern or foreign syndicate. The *Mining and Scientific Press* (San Francisco) puts in a word in behalf of such owners, and says:

> There are no doubt many cases where actual benefit would result if an owner did not have quite so secure a hold upon his idle property. But every man has a right to do what he will with his own. . . If it is not possible to obtain absolute title to mining ground, the industry would be destroyed, or, at best, it would be terribly crippled.

It has been the aim of the law-makers in the United States and the Spanish-American countries to accomplish two results,—to encourage the active development of the mineral resources and at the same time to secure owners in their holdings. To gain these two things laws have been framed whose provisions are in a measure antagonistic. First, to compel the claims to be worked, there is the assessment-work plan (temporarily suspended in the United States), which requires the owner to do a certain amount of work each year upon his claim, the penalty being forfeiture of title and liability to having the claim "jumped" by any one who considers it worth taking up—and, in the early rough-and-tumble days, who was strong enough to hold possession. Then there is the patent system, intended to firmly secure title to owners who have gone through certain forms of locating, having official surveys made by government deputy surveyors, advertising intention, paying certain fees and doing certain work; after which, a patent having been issued through the land office, the theory is that the title is safe in perpetuity. There is no question as to the good intent of both systems, nor that they are skilfully elaborated with the view to working side by side with as little friction as possible. It happens that there are unavoidable weak points in both cases. Assessment work has always been more or less a farce, and it has been a source of uncertainty, either at the time or subsequently, to determine whether the required work has or has not been actually performed. This has led to interminable legal wrangles, to say nothing of personal collisions. On the other hand, the patent system of ownership does not afford perfect security, any more than does the patent on an invention, both being open to later adjudication whenever there is enough value to contend for. If the whole of our intricate mining laws could be wiped out, and a simpler system substituted which, without being retroactive, would for the future bring the ownership of mineral ground to the same plane as that of ordinary real estate, it would be a great improvement. Then, as now, but more strongly, could be endorsed the saying of the *Mining Press* that "every man has a right to do what he will with his own," it being understood that no direct injury is done, though a negative loss might be claimed as affecting the general prosperity of the commonwealth—which is a nice question. However, the great trouble at present is not that there are unnecessarily idle mines, but that it is so difficult to really secure ownership.

A PRELIMINARY statement of the production of copper in the United States in 1893, by Mr. Charles Kirchhoff, Jr., gives the total domestic output at 329,692,461 pounds. In the year 1893 there were 7,623,387 pounds of copper produced from imported ores and pyrites. Imports of metal in pigs, bars, ingots, and "old," were 5,536,696 pounds. Exports were smaller—113,984,128 pounds of metal. The fine copper contents of matte exported were estimated at 50,000,000 pounds. Reëxports of foreign ore and ingot copper were 2,019,821 pounds. The total available supply at the close of the year was 176,948,589 pounds, a notable decrease from the stocks on hand at the close of the preceding year.

A NEWSPAPER devoted to the mining interests, speaking of the recent disaster at the Gaylor colliery at Plymouth, Pa., betrays a queer notion of what "pillars" in coal-mines are. It naïvely explains to its readers, in order that they may have a clear understanding of the situation at the time of the accident, that "in mining coal in the vein"—as though there were any other place to mine it than in the vein [bed]—"massive pillars of coal are left standing to support the roof, forming *a natural colonnade*," and so on. This architectural concept of the appearance of the workings of a coal-mine is ingenious and a stroke of imagination on the part of the editor who evolved it from his inner consciousness, but hardly serves as a basis for lecturing the miners.

THE basic process of steel-making, which has been steadily gaining ground in Europe, is greatly helped by the use made of its by-product, phosphoric slag, now largely used in agriculture. This process, also known as the Thomas, treats ores containing a notable percentage of phosphorus, which until the introduction of the process, had always been the great bugbear of steel metallurgy. Indeed, within limits, there is a great demand for phosphorus in the ore that actually makes what would formerly have been considered unmarketable ores much sought after, this demand for phosphorus being partly due to the requirements of the process itself, but latterly still more so for the sake of the slag by-product, which sells according to the percentage units of phosphorus contained, just as do our South Carolina and Florida natural phosphates. It is stated in a French technical journal (the *Côte Libre*) that the phosphoric slag realizes almost as much as the pig itself from which the phosphorus has been removed. In this way the basic has an advantage over the Bessemer process, the slag or scoria from which is of no value for the purpose. Bessemer slag has, however, been used in a small way for making brick and cement, by being granulated by pouring while molten into water, the granulated material then being dried and mixed with lime.

FLOATING in the "reprint" columns of the press is found the following uncredited paragraph, evidently an excerpt from some longer article or essay:

> The volatility of metals furnishes an interesting subject for modern science. Its study in a practical or commercial sense cannot fail eventually in the development of processes directly affecting the metallurgical world, both in methods and character of products. Elements hitherto refractory have by recent experiments been removed or changed. Iron, copper, gold, silver, tin, platinum, aluminum, and manganese are all included as capable of distillation. Silicon and carbon submit to the same process, and refractory alkaline earths are said to be on the same list. The chemist in metallurgy is becoming one of its most potent factors.

Notwithstanding the sophomoric tone, and the author's apparent ignorance that in the metallurgy of quicksilver, zinc, arsenic, etc., volatility has from time immemorial been the central feature of extraction processes, there is a kernel of sound truth in the foregoing sentences. Now that the electric furnace, with its high power, controlability, and considerable capacity, is available at reasonable cost, and while the sun-furnace remains a possibility, there is certainly opened a wide field for new lines of experimentation, with a very fair chance of some startling practical results that might revolutionize certain branches of metallurgy. Yet it must be admitted that, in treating the more valuable metals and their ores, the metallurgist would very gladly spare from them this quality of volatility, which is not only a nuisance, but also a direct source of loss. However, seeing that the quality is there and cannot be suppressed, the next best thing will be to seek to make the most use of it, with the advantages of the high temperatures now attainable.

IT is stated that the Semet-Solvay process of coke-making, employed in France, and the Otto process, in favor in Germany, give per ton of coke burned 5½ kilograms of sulphate of ammonia, which is worth, according to the condition of the market, from 250 to 300 francs per ton. American coke-makers who are fully alive to all progress in the direction of improving the quality of their product, and whose works are models in the way of mechanical economies carried out by working on a very large scale, have not yet fairly turned their attention to the question of by-products. Of course there is a great deal besides this in the old controversy between the beehive and the "patent" types.

THE Comstock lode, Nevada, has presented some of the most difficult problems in mining, but it has also been the scene of some wonderful achievements, among them many involving the introduction of entirely novel expedients. Nobody ever claimed for it a reputation for economy, but it certainly has furnished examples of daring engineering and also of very rapid work, considering the disadvantages. A recent discussion of rapid shaft-sinking has led the Virginia City *Enterprise* to furnish the records here quoted. The Savage, Norcross, and Chollar joint shaft, known as the Combination, has four full-sized compartments, each six feet in length by four feet in width, requiring an excavation nearly forty feet in length by seven in width to allow room for timbering. This shaft was sunk to a depth of more than 2500 feet, and closely timbered with 12 × 14-inch timbers, in two years, and several working stations were opened at the same time, each capacious enough for a dance-hall. The joint Best & Belcher and Gould & Curry shaft, known as the Osbiston, was sunk to a depth of 2000 feet below the surface in 18 months. This shaft has three compartments. Both of the above shafts were sunk through a diorite formation, requiring heavy blasting for almost every foot attained in depth. A record of 110 feet a month has frequently been made by Comstock mining companies in sinking. For rapid drifting the Comstock has never been excelled. On the 3100-foot level of the Combination shaft a south drift was advanced 115 feet in one week, and this with a cloud of steam arising from the water in the sump, showing a temperature of 120 degrees; meanwhile the ponderous hydraulic pumps were lifting to the Sutro tunnel level nearly 4,000,000 gallons of this steaming water every 24 hours. The speed of driving the Chollar drift is said to have been excelled in several instances, but that in the Chollar is the longest drift ever run on the Comstock at that depth.

THE output of gold in the United States in 1893 is estimated by the treasury department at $37,000,000, an increase of $4,000,000 over that for 1892. This gain is the natural result of the greater attention paid to gold-mining since the silver-mining became, with few exceptions, unprofitable. About one-half of the increase is attributed to Colorado, where the Cripple Creek gold-mining district has begun a considerable production, which promises to be increased in the future. It is expected that the current year will show a further advance in the total gold production, to which the partial revival of hydraulic mining in California will contribute, while in general all the sources of gold in the country will be stimulated into greater activity.

A DEVICE for not merely eliminating but also utilizing the smoke of soft coal has been tried in the mint at Birmingham, England, and, it is said, successfully. According to the account it certainly surpressed the smoke, but there must be an added expense in its application, with some disadvantages as to draft. The apparatus is comparatively simple, consisting of a large water-chamber in which a horizontal agitator works at 280 revolutions per minute. Outside this tank, and connected with it, is a high-speed fan, running at 3000 revolutions and also connected with a tall chimney at its lower part. The fan intercepts the smoke, forcing it through the condensing-tank, where the carbonaceous matter, sulphurous acid, and metallic fumes are caught in the water. A circulation of the water is made between the tank and a trough, and both are drawn off when sufficiently charged. The residue of the products of combustion, not condensed, passes from the chamber, entering the chimney at a point about forty feet up and thence escaping from the top as a thin, white vapor. The fine carbon collected is sold for electrical purposes and the sulphates in the liquor converted into a disinfectant. In the case of a mint or other metallurgical works we suppose the idea is also to effect a saving in precious metal. So far as the elimination of smoke is concerned, it is generally admitted that the best plan is prevention, not cure; that is, to secure a perfect combustion in the furnaces. For condensing metallic fumes this device may or may not act as efficiently as the ordinary water-spray. But at the best appointed metallurgical works reliance is placed upon long series of dry flues and dust-chambers connecting with very tall stacks, and having the combined draft of the blowers which feed the smelting-furnaces, auxiliary fans, and, finally, the natural draft of a high stack. At the Omaha and Grant Smelting Works, at Denver, the whole system of flues and dust-chambers is over a mile long, connecting with a main stack 350 feet high, the tallest in the United States.

THE bureau of anthracite statistics of Pennsylvania reports the anthracite shipments in 1893 at 43,089,585 tons, a gain of 1,894,320 tons over the shipments of 1892. The annual trade statement prepared by Mr. William H. Riley, showing that the consumption of anthracite in 1893 was larger than ever before, says that this was one of the anomalies of the year, occurring in the face of a general falling off in mineral production. In round numbers, the consumption of anthracite in 1890 was 36,300,000 tons; in 1891 it rose to 40,200,000 tons; in 1892 it again advanced, to 42,000,000 tons, increasing another million tons last year. The Wyoming region is now the leading producer, while the Schuylkill has fallen behind and the Lehigh region has increased slightly.

IN mines yielding sulphid ores, especially of copper- and iron-pyrites, the mine-water often becomes very destructive to the iron pumps and pump-columns. As the mines are opened and the ore becomes exposed to the air, oxidation takes place, forming soluble sulphates and, in certain reactions, free sulphuric acid. The corrosive effect of a copper sulphate in the water is probably due to the exchange of iron for copper in the precipitation of the latter by the former, though miners commonly ascribe it to simple free acid. The superintendent of the Gagnon mine at Butte, Montana, reports that there is considerable water constantly leaching down through the old stopes, and in so doing it seems to become impregnated more or less with sulphuric acid, which acts on the columns and pumps. He adds: "There is quite a difference in the character of the water in the different parts of the mine. The silver-mines do not have water that is particularly troublesome, but in the copper-mines there is a great deal of trouble. . . . Some 2½ years ago we put in a 7-inch column to throw this water to the surface, and for awhile it showed no particular corrosive action, but during the last spring a corrosive action on the iron was very apparent, and the surprising thing about it is that the action showed first at the top of the column. As it went on more leaks occurred, until one length of pipe of 15 feet had thirteen clamps on it. It was fully determined that we must use something besides iron, but just what ought to be used is a serious question. There is one copper column in the mines in Butte, but copper is so expensive that it is almost out of the question for us to think of duplicating that column. There is also one brass column 5 inches in diameter, but I understand there is some objection to that. I think it is probable that we will have to come down to using iron pipes lined with wood, which is the cheapest method I know of for keeping the water away from the iron."

Tarring the iron of the pumps and

columns, or the application of asphalt varnish, gives some protection. Wooden pipes (either bored logs or boxes) have been used in such cases where the pressure was not too great. One superintendent in Colorado seriously proposed to put in a rubber column for a 500-foot lift, but was laughed out of it. For small pressures and volumes rubber hose might answer. But in deep mines, having heavy floors of water to contend with, it is a serious problem what to use in place of exposed iron in pipes and other underground appliances, where the water is corrosive. Makers of underground machinery sometimes substitute bronze or brass in part for iron and steel.

MANGANESE steel containing varying proportions of manganese shows remarkable differences in behavior in tests, even when the percentage change is but slight. Not only this, but the results are not always what might be predicted in advance of experiment, and are often very puzzling. Mr. R. A. Hadfield, the distinguished Sheffield metallurgist who has for many years made a special study of this interesting series of alloys, in a paper on "Iron Alloys with Reference to Manganese Steel," gives the results of his experience in the manufacture of cast manganese steel. He has been led to believe that a special explanation of its qualities of toughness and resistance to fracture is needed. It has been commonly imagined that what is known as toughened material is secured in the casting without additional treatment. This is not so. Although the metal, even in its cast state, is sometimes remarkably tenacious and ductile notwithstanding its hardness, a further treatment, such as water-quenching, gives the best results. Mr. Hadfield is inclined to think that the variation noticed in its properties is somewhat dependent on the casting temperature and other similar causes, some of which are not yet fully understood. In all cases there is a great difference between the strength of 10 or 12 per cent. as compared with that of 5 per cent. manganese steel. The former is improved by water-toughening; the latter is not, and is of little use. It is at about 14 per cent. that the maximum of strength is obtained. Beyond that point there is a decrease, but the true cause is made complex by the higher percentage of carbon which goes with higher manganese. Mr. Hadfield believes that if the carbon could be reduced there would be considerable strength in alloys of 25, or even 30, per cent. manganese, and that such products would be forgeable. The entire paper should be consulted by all who are interested in recent advances in this important branch of metallurgy.

THE mine which is at present the greatest silver-mine in the world is the Broken Hill Proprietary, of New South Wales. Besides silver, it yields also gold, considerable lead, and some copper. For the six months ending November 30, 1893, it exceeded all its previous records by turning out 6,533,232 ounces of silver, 1431 ounces of gold, 25,822 tons of lead, and 333 tons of copper (in matte). This was from 260,047 tons of ore treated.

THE Johannesburg *Star* quotes the report of the chamber of mines of that place for 1893, which gives the total output of gold in the Randt district of the Transvaal at 1,479,114 ounces for the year. This is by far the best record yet. In 1890 the production was 494,810 ounces; in 1891 it was 729,233 ounces; in 1892 it had increased to 1,210,865 ounces. This steady progressive gain is one of the most encouraging features of the great gold-mining region of South Africa.

AGAIN a story comes of a wonderfully rich gold find having been made in the Colorado desert, with the comment that the miners think the discovery is where the Indians used to obtain the gold they showed to people in Caliente. This region is the favorite source of myth and romance —also of frequent disappointment and disaster. There really should be something there, on the principle that where there is much smoke there must be some fire; and there certainly have been enough reports to point to some basis for them.

CIVIL ENGINEERING

Conducted by John C. Trautwine, Jr.

IF William of Normandy could revisit the country he conquered some eight centuries ago, he doubtless would find much to astonish him, but perhaps nothing would come home to him with greater force than the sight of the great stone towers of the new Tower bridge, with their feet planted in the bed of the Thames and their heads reaching far above that of the famous "White Tower" of London built by the Conquerer himself, and still standing hard-by.

He would no doubt inspect the great structure under the guidance of Mr. John Wolfe Barry, the engineer-in-chief, who so courteously took the visiting American engineers over the foundation-works in 1889, and he would then note at least one essential difference between these modern towers and his own construction. Whereas the latter was just what it professed to be, a great jail and fortress, the former are, to a great extent, a sham and a pretense,—very real, indeed, and built of no sham materials, but sham in that they do not uphold the working parts of the structure, but merely hide from view the steel skeletons which actually perform this service. They thus not merely put themselves forward as doing a work which they do not do, but, like some of their human prototypes, conceal from view the real benefactors whose reward of praise they fraudulently reap for themselves. The grim fortress which was begun by the Conqueror about 1078, and which is still practically as good as new, if not better, stands close by the north or left bank of the river, a half-mile below London bridge; and the approach to the new bridge, to which it gives its name, climbs close along the south wall of the old Tower.

UNTIL the building of the present structure the world-renowned London bridge was the most seaward of the bridges over the Thames, and from that point downward the only means provided for crossing the river were the Thames tunnel, built by Brunel in 1825–43, the "subway" (for foot passengers only), and the ferries. But for many years the inconvenience of being obliged to use London bridge has been a very serious one to the enormous traffic crossing the river at this east end of London, for this meant not merely a serious detour to reach the bridge; the bridge itself is so narrow as to offer but a very insufficient highway for the stream of vehicular traffic crossing it. The roadway of London bridge is only 35 feet wide; yet the daily travel over it in 1892 amounted to over 22,000 vehicles and 110,000 pedestrians. The extent of the traffic demanding a crossing lower down stream may be inferred from the fact that below London bridge lies all that very important portion of work-a-day London which derives its business from the river, including the world-renowned docks, of which nothing in this country gives one the least conception. And yet so important is the shipping interest in the Pool, as that portion of the river lying just below London bridge is called, that the idea of submitting to a further throttling of the narrow stream by the building of a permanent bridge lower down could not be entertained.

After many plans had been submitted and duly considered, and after any amount of scheming and counter-scheming, both in and out of Parliament, the present remarkable design was adopted.

THIS design involves a channel-opening of 200 feet, with two bascule leaves, and a permanent overhead footway served by elevators running in the piers. The shore spans (one on each side of the river) are 270 feet each, and are upheld by suspension "chains" stretched between the great towers already referred to, and shorter ones near the shores, while the overhead footway, with 141 feet headway above Trinity High Water, joins the tops of the principal towers.

The so-called main "chains," which support the two 270-feet shore spans, and which depend from the high main towers of the channel span at one end and rest upon the lower abutment towers at the other, are in fact formidable riveted structures. Each "chain" is in two halves, pivoted together where they meet at their lowest points near the roadway, and pivoted at their ends to the backstays or "land-ties" and to the high-level tie over the opening span, respectively. Each main chain has an upper and a lower chord, in the form of a box-girder, and the diagonal bracing which connects these two chords is also box-like in cross-section, while the land-ties and the ties over the opening span are composed of plates, riveted together, and are provided with pin connections at their ends.

The trusses for the high-level footways are of riveted lattice construction. There are two of these elevated foot ways, one on each side of the bridge, and served, as already intimated, by elevators running in the towers; but, as one never takes an English elevator (or "lift") except when there is plenty of time to spare, stairways are also provided for such pedestrians as may be in a hurry.

The two bascule leaves weigh very nearly 1200 tons each, and each is composed of four main girders on a steel shaft 21 inches in diameter. Each girder is a riveted braced half-arch. The bascules are counterpoised by weights of lead and of iron, and are worked by two hydraulic engines of 360 horse-power each, located on shore and operating two accumulators in each pier. The main piers of the Tower bridge are oblong in plan, and each consists, essentially, of four octagonal steel riveted steel columns, about six feet in diameter and 120 feet high, with parallel sides and braced, at intervals of about three feet, by horizontal plate diaphragms, with openings for the passage of the elevators. The four columns of each pier are braced together by three landings, which are connected by diagonal bracing in the plane of the sides of the piers.

EACH of the two main stone piers is 70 feet wide and 185 feet 4 inches long, and the bases of the foundations are about 93 feet below the main roadway, or 60 feet below Trinity High Water. Each pier foundation was constructed within a coffer-dam composed of twelve plate-iron caissons, which were sunk 15 feet into the London clay in the bed of the river. The caissons were about 2 feet 6 inches apart, but, after two adjoining caissons had been sunk, the space between them was cut off from the river by means of square piles driven at the ends of the space between the two caissons and the two adjoining sides of the caissons were then removed. The twelve caissons thus formed, when driven a continuous double coffer-dam around the site of the pier.

The imperviousness of the London clay rendered it practicable to excavate it to a depth of five feet below the foot of the coffer-dam and to the same distance beyond its walls. A bed of concrete about twenty-seven feet thick was then deposited, filling the excavation thus made and extending up to the level of the river-bed. Upon this was started the outer shell of masonry of the pier. When this was completed, the upper or temporary portion of the coffer-dam was removed, and the masonry shell then formed the coffer-dam for the work of filling, which went on inside. The lower portions of the coffer-dams, nineteen feet deep, remain permanently in the work.

THE Tower bridge will bring a pressure of about four tons per square foot upon the London clay of the river bed. It was estimated that the settlement, under this load, would be about 3 inches, but observation shows that it will be somewhat less than this. A trial cylinder, loaded to the same extent, showed 1⅜ inches settlement after three days. At the Charing Cross bridge, which crosses the river a mile or two higher up, six tons per square foot were required to produce a settlement of three inches, while eight tons per square foot, which is the pressure on the foundations when the bridge is loaded with locomotives, produced a settlement of four inches.

THE corner-stone of this great work, involving, as it does, the construction of the largest river piers in the world, with the exception, perhaps, of those of the Brooklyn bridge, and an application of the bascule principle upon a scale hitherto unprecedented, was laid by the Prince of Wales on June 21, 1886. The work is now practically completed.

It will be noticed that only pedestrian traffic is here provided for at all times. Vehicles must await the closing of the draw. In fact, the difficulties of the situation were such as to call forth a large number of original and radically-different schemes for effecting this crossing with a minimum of interruption to the two conflicting interests involved. Among these was the design of Sir G. Barclay Bruce, afterward president of the Institution of Civil Engineers. This contemplated a rolling platform, 300 feet long, which was to slide upon rollers placed upon the tops of six piers spaced 100 feet apart, so that the platform should, in any position, rest upon not less than two of the piers. Of three dedesigns submitted by Sir Joseph Bazalgette, who was president of the Institution in 1884, one at least involved a spiral ascent with 150 feet radius on the south or Surrey side of the river. A design by Messrs. Knipple and Morris employed, instead of the overhead footway of the present design, a tunnel under the channel span. The ends of this tunnel communicated with the roadways on the shore spans by means of vertical shafts provided with lifts. These lifts were designed to carry not only pedestrians, but vehicles as well, and the design thus had this great advantage over the one adopted, that vehicular traffic should proceed at all times. This advantage was possessed, also, by several designs submitted, in which the roadway, at one or more points in the crossing, was divided into two branches, which came together again, embracing between them an opening for vessels, each branch being provided with its own lift-, draw-, or swing-bridge. The two branches, with the space enclosed between, thus constituted, in effect, a lock through which vessels could always pass, while at the same time one of the two branches of the roadway was always open for both pedestrians and vehicles.

MR. JOHNSON, acting secretary of the New Decimal Asssociation (London), issues a statement designed to bring home to the conservative mass of his fellow-countrymen (not to mention our own) the practical disadvantages of their refusal to adopt the metric system, as viewed from the stand-point of *£. s. d.* Hitherto the opponents of the metric system, while admitting that it may be all very pretty theoretically, have insisted strenuously upon the immense inconvenience and the enormous money loss that would be involved in its adoption, and the advocates of the system have seemed to acquiesce, to some extent, in the line of battle thus mapped out for them by the enemy, and to content themselves with enlarging upon the manifest advantages which the new system offers to the calculator; and it is therefore not altogether strange if the masses have come to regard the metric system as a costly scientific toy, which it was proposed to place in the hands of the scientists at the expense of the aforesaid masses. But Secretary Johnson quotes the latest report of the foreign office, to show that British trade fails, by reason of its adherence to the barbarities of the non-metric system, to obtain that foothold among foreign nations which it might otherwise enjoy. It is urged that the metric system is now employed, for instance, throughout Bulgaria, and that it is idle for English manufacturers to expect the Bulgarians to give themselves the trouble of learning the puzzling English weights and measures for the sake of sending their orders to English houses, while the representatives of more enlightened nations stand ready to treat with them in the rational system which they have adopted. British manufacturers, it is said, do indeed unbend to the extent of issuing their catalogues in the French or in other foreign languages, but they continue to refuse to conform to metric measures. Such conformity must of course extend beyond the catalogues and must enter into their manufactures, and here, of course, is the rub; yet it can hardly be doubted that if our British cousins (again preserving silence respecting ourselves) can be shown that it will pay them to adopt the metric system, they may be induced to submit even to this innovation.

A correspondent who has occasion to ship from England to Peru, complains bitterly of the trouble to which he is put by being obliged to make out his shipping specifications twice over, first in English and then in metric weights and measures; but it is doubtful whether this appeal to the British humanitarian instinct will exert as potent an influence as that which the Secretary makes to the British pocket.

AT a recent meeting of the French Society of Civil Engineers a curiosity was presented in the shape of a pamphlet on compressed air, written a half-century ago by the late Tessié du Motay, and suggesting an infinite variety of applications of compressed air to a great number of industries, including a drawing of a locomotive operated by that means upon an ordinary railway in Paris in 1840.

AT the same meeting a paper was read describing the recent experiments of M. de Mas upon the resistance of boats to traction. These experiments have been in progress for about four years and have been confined thus far to cases where the cross-sectional area of the channel may be regarded as indefinitely great, relatively to that of the vessel passing through it. It was found that with a draught of 1.6 meters, velocity 1.5 meters, the addition of a strip of oil-cloth or wax cloth (*toile cirée*) 1.26 meters wide, resulted in a reduction of 13 per cent. in the force required for traction, while a coating of the same material, extending over the entire submerged surface, gave a reduction of 30 per cent. These results strikingly confirm the principle advanced by Darcy and Bazin, and elaborated by Ganguillet and Kutter, of the important influence exerted by the character of the wetted surface of a channel or pipe, upon the velocity of the water flowing through it; for the same principle of course applies equally, whether the water flows through the channel or whether the boat is drawn through the water. Enterprising boatmen recognize this to some extent, but it seems probable that very great economies might be effected by still further refinements in this respect.

Experiments at different velocities upon the resistance to traction exerted by vessels of different lengths indicated that the length of the vessel exerts very little if any influence upon the resistance, thus confirming the position maintained by Du Buat, who argued that the resistance due to the form of the vessel consists of two parts, namely, the head resistance, which is independent of the length, and the backward vacuum-like action at the stern, which is inversely as the length; that the friction of the sides is directly as the length, and hence that the total form resistance is independent of the length. M. de Mas, experimenting with spoon-shaped bows, resembling those of the American "whaleback," obtained by their use a reduction of 75 per cent. in the cost of traction; and in this he found his results confirmed by those of Klepsch, of Weimar, who has simultaneously been carrying on similar experiments. At this point M. L. de Chasseloup-Laubat, who will be agreeably remembered by those of our readers who had the pleasure of meeting the visiting engineers of the Société des Ingénieurs Civils de France in September last, remarked that he had found this spoon-shaped bow generally adopted in America and that its advantages were strikingly shown in the recent international yacht race between the *Vigilant* and the *Valkyrie.*

IN the matter of river-pollution Great Britain seems to hold the palm among civilized nations. The writer well remembers the condition of the Irwell at Manchester in 1889, at which time it was being subjected to the meliorating influences of Dr. Albert Leeds, of Hoboken, and is inclined to think that it threw even the shady Chicago river and the equally dark Gunner's run of Philadelphia into the shade. Glasgow has been awakening to the necessity of avoiding the pollution of the Clyde by her own offal, and has recently installed a sewage-purification plant draining an area of 2600 acres, with a population of 270,000. The works handle at present about 10,000,000 gallons daily, or about one-fifth of the total product of the city, and it is claimed that they are so arranged that their capacity can be easily and cheaply doubled. The system employed is that designed by Mr. G. V. Alsing, C. E., and successfully used at Sheffield. The works at Glasgow were executed under Mr. Alsing's charge. They occupy a site lying within a sharp bend in the river, and the sewage is brought to them through a 7-foot conduit. Solid matters suspended in the sewage are first removed by strainers consisting of endless vertical traveling screens arranged after the manner of link-belting, and the sewage then passes to two catch-pits, in the bottoms of which are V-shaped grooves provided with revolving conveyor-screws which force the remaining heavy matter to a sump, from which it is lifted by bucket elevators and deposited in cars. The sewage then flows to a well, from which it is lifted by four centrifugal pumps with a combined capacity of over one million gallons per hour, to a delivery main. It is then treated with lime and sulphate of ammonia, and passes through an open channel to the precipitation- and aëration-tanks and thence to the filters, from which it issues as " a perfectly clear and odorless liquid, devoid of all injurious properties," to the river. The filters are filled with coke, which, after it has become foul, is burned under the boilers. The sludge is treated with 1 per cent. of lime, to give it adhesion, and is then pressed into cakes by compressed air, and is used as a fertilizer on the farms recently purchased by the city for the purpose of raising fodder for the large number of horses used on the tramway system of the city, which becomes public property during the coming summer.

Thus does the massing of extended industries under the control of a single organization permit the application of reforms which otherwise would be impracticable. These works are practically completed. The total cost, including the 27 acres of land occupied, was $500,000, and the cost of operation will be about $50 per million gallons treated.

THE name of the microbe having become, in the popular ear, synonymous with sewage-pollution and with all the diseases which we naturally associate with it, it must occasion surprise to be told that the purification of sewage by filtration depends upon the action of beneficent microbes living and acting in the thin layer of slime which surrounds the sand-grains in the filter; yet such is the verdict of modern investigators. Of course, these benefactors, after they have done all they can for us, are ruthlessly destroyed, and their places taken by their successors; yet while they live and are permitted to work for us, they insist upon an adequate supply of oxygen for purposes of respiration. Mr. Sydney Richard Lowcock, Assoc. Mem. Ins. C. E., has recently been experimenting upon the effect of artificially supplying air to the sand used in filters, and has found that by such aëration the area of the filter-bed required for a given number of inhabitants may be reduced about 90 per cent. It will at once be seen that, if these results are borne out in practice, they must go far to extend the practice of sewage-filtration.

THE state of Massachusetts leads America in the matter of the study of water- and sewage-purification, and the reports of its board of health are recognized throughout the world as forming one of the most important sources of information in these matters. The board holds itself ready to give advice to those cities, towns, corporations, and individuals who apply to it for advice relative to systems of water-supply, drainage, and sewerage; and some seventy pages of the last report are made up of replies given by the board in response to such queries. The following extract from a reply given by the board to the Naukeag

Water Company, of Ashburnham, may serve to illustrate the character of the information conveyed:

> The leakage from the reservoir at the present time permits a large amount of water to escape under the dam. This leakage should be prevented as far as practicable. It is probable, however, that a comparatively large amount of water will still flow out of the ground below the dam, so that the largest additional supply can be obtained by intercepting this water. Ditches extending out from both sides of the reservoir to intercept and divert into the reservoir the water which now flows past it on either side will also add to the supply.

This suggests the question: To what extent will the exercise of this beneficent office on the part of the state board conduce to the prosperity of the individual practising engineers of the commonwealth?

THE Massachusetts board investigates the character of the water-supplies and of the various river waters of the state, and compiles and publishes statistics regarding them. At the Lawrence Experiment Station (described by Mr. George W. Fuller in this Magazine for February) very important experiments upon the purification of sewage have been made. The writer has had the pleasure of spending an afternoon at this station, under the excellent guidance of Mr. Allen Hazen, the chemist-in-charge, who, in response to a request for a glass of water, filled a glass from a faucet and presented it as the effluent from the filters into which the town sewage was fed. It proved to be, so far as one could learn from observation and taste and from the absence of all unpleasant after-effects, a perfectly satisfactory drinking-water.

Mr. Hazen has been conducting some elaborate experiments upon the physical properties of sands and gravels, as related especially to their behavior as filtering materials. He finds that within certain limits of size of grain and of rate of flow the frictional resistance of sand to the flow of water through it varies directly as the rate of flow and as the depth of the sand (as stated in what is known as Darcy's law), with the temperature, being twice as great at the freezing-point as at summer-heat, and inversely as the square of the effective size of the sand grain, the "effective size" of a sand being that diameter below which one tenth (by weight) of all the grains are found. The friction, at the beginning of each experiment, is always higher than at later periods, because of the air in the sand, and this state of things does not disappear for several days. It is found that at a temperature of 10° C., and with an active head equal to the depth of sand, a sand whose effective size is 0.10 millimeter and whose pores are entirely filled with water and free from clogging, will pass 10 cubic meters of water per day for each square foot of sand surface. As already stated, the rate varies directly as the square of the effective size.

THOSE who had the pleasure of visiting the great exhibits of the Pennsylvania and Baltimore and Ohio railroads at Chicago last year will be gratified to learn that it has been arranged to place both of these exhibits in the Columbian Museum in that city, with Mr. J. Elfreth Watkins as director. Mr. Watkins, it will be remembered, was in charge of the Pennsylvania railroad exhibit. The Conductor understands that Major J. G. Pangborn, who similarly presided over the exhibit of the Baltimore and Ohio railroad, will make a tour of the world for the purpose of collecting other objects of interest, to be added to the collection.

THE Conductor finds himself incapable of excluding the following item from his train, even though his failure to do so may seem to smack of the shop. It comes from a correspondent in Honolulu and gives a conversation which is said to have taken place in Oakland, California:

> WIFE (*to* GEORGE, *who is searching in his library*)—What are you looking for, George?
>
> GEORGE—I'm looking for my "Trautwine."
>
> WIFE (*misunderstanding*)—What on earth can you want with a trout-line at this time of night?
>
> GEORGE (*ditto*)—I want a coefficient.
>
> WIFE (*ditto*)—Want to go a-fishing? Who ever heard of *your* going fishing?

MECHANICAL ENGINEERING

Conducted by Henry Harrison Suplee.

THERE has been more or less discussion about the recent informal meetings of some of the members of the American Society of Mechanical Engineers at the rooms of the society, the impression being somehow current that they are meetings of the society itself, and that as such the papers and discussions should be included in the Transactions. It is satisfactory to see that such an interest is taken in these informal meetings, as the very tone of the criticism implies that the discussions are of sufficient value to make their permanent record desirable. But to insist that the meetings should be made "official" is as absurd as to object to the discussion of engineering topics by members in the rooms of the society at any time without the presence of a reporter and the publication of their words. It is true that the ripest experience of some of the ablest members of the society is often brought out in the course of a quiet conversation in an odd moment, without premeditation, and sometimes in the absence of those who would have been the most appreciative listeners; and one would often be glad to be able to turn to a report of some animated conversation which can be recalled in later days only as something to regret having forgotten. An informal meeting is nearly always the best kind of a gathering to develop the most valuable kind of professional conversation, and, while such meetings would lose their special value if they became official, it is the highest compliment which could be given to them to find absent members troubled when they discover the value of what they have missed.

The relations of such meetings to the regular conventions of the society may become somewhat like those of the *privat docent* of the German universities to the regular professor, the former being a sort of free-lance, lecturing on his own account to such students as choose to attend, but keeping the regular professor always on his mettle lest the irregular instructor be found so efficient and capable as to draw away his students and leave him addressing empty benches. If the informal meetings prove too attractive and their discussions more desirable than the regular Transactions, there must certainly be a friendly rivalry created between the active members at the unofficial meetings and the regular publication committee, which can result only in a most beneficial stimulus to the latter, spurring it to increased efficiency, with correspondingly more valuable results. There is ample room for both official and unofficial meetings, and it is a most encouraging sign of the energy of one of the most active of the great engineering societies that there should be just such lively interest and emulation.

ONE difficulty in securing papers of high practical value for the meetings of engineering societies lies in the fact that the very men from whom the most valuable material ought to be obtainable may not have the time to prepare papers or such facility in technical writing as to render the task an agreeable one. There is no doubt that very many of the papers presented before such organizations are the work of investigators and men of research rather than records of experience, although there are many purely practical contributions to be found in the pages of the transactions of all such societies. The portly volume containing the Transactions of the American Society of Mechanical Engineers for 1893, however, illustrates more than ever the fact that, notwithstanding the great value of the original papers presented, the most interesting portions are the discussions which the papers elicit and stimulate. As the old Arab proverb has it, "the lesson is one, but the talk that follows the lesson is one thousand," and, either as a talk at the conventions or as a printed discussion appended in the completed record, there can be little doubt that the searcher after practical information from the practical men will turn with pleasure and profit to the discussions which add so much to the value of the book.

Not the least interesting of these discussions are those provoked, so to speak, by the "topical queries," which indeed often receive too little attention, though they rarely fail to elicit points of interest which, however familiar they may be to some of their hearers, are nearly always new to others. A man will always hesitate to attack or criticise a paper in writing unless he has had an opportunity to examine it carefully beforehand, while the verbal fencing by men who know whereof they speak often becomes vastly profitable and entertaining as well, one point suggesting another until one is surprised at the number of interesting features which an apparently simple query has developed.

THE contest which in earlier times existed between the man-at-arms and the knight on horseback, and which in modern days has been transferred to guns and ironclads, appears in another phase in the latest developments of attack and defense as existing between burglars and safe-makers, and as this branch of work, on the side of the defense at least, may properly be included as a division of mechanical engineering, no apology is needed for introducing it here. The appropriateness of including the subject of safe- and vault-construction in the scope of mechanical engineering is confirmed by the fact that the commission of experts appointed by the United States government to report as to means of improving the vault facilities of the treasury department was composed entirely of mechanical engineers,—namely, Professor R. H. Thurston, of Cornell; Mr. F. A. Pratt, of the Pratt & Whitney Co.; and Mr. Theodore N. Ely, of the Pennsylvania Railroad Co.,—and the report which this commission has just made to the secretary of the treasury is most interesting.

The commission visited the leading establishments in which such work is made, besides witnessing tests of the resistance (or lack of resistance, in most cases) of the various burglar-proof receptacles, and some of the results are anything but assuring to institutions hitherto supposed to be reasonably well-protected. There may be some consolation in the knowledge that probably Uncle Sam is worse off in this respect than almost any private establishment, but the only salvation for the treasury vaults at present appears to be the strong guards maintained there. Just now the makers of bank-locks appear to be ahead of the vault-builders, and what with the automatically operated bolt-devices, and beautifully constructed time-locks with all parts duplicated and many of them tripled and even quadrupled, the danger either of illicit entry or of accidental lock-out in connection with the locking devices is extremely remote. While the combination of layers of hard and soft steel, Franklinite, chilled cast-iron, and the like may offer many difficulties to the burglars in the limited time which is usually at their disposal, yet it is rather mortifying to read that any tests of such constructions to be of real value "must ultimately be finally made by experimenters of more experience, and professionally more expert than even the safe-makers"—*i. e.*, the burglars themselves—and that "experimental investigations of the vulnerability of such structures have been very seldom and very incompletely made—except by burglars." As a matter of fact these gentry have invariably shown themselves entitled to most respectful consideration as mechanical engineers, and the lock-makers and vault-builders have scarcely been able to keep pace with them, even by the introduction of time-locks, automatic bolt devices, refractory materials, and the like; since the use of liquid explosives, blowpipes, special tools, and general ingenuity has constantly kept the defenders on the anxious bench.

It now looks as if the old story of the knight in his armor against the peasant with his musket was about to be repeated in this later struggle, and that heavy armor may be abandoned altogether in favor of alertness and watchfulness, assisted by all manner of electric alarms and guards. As speed is the all-important question in the modern cruiser, so prompt alarm is likely to be the main question in coming burglar-defense, and it may end in leaving the funds exposed to full view on a table which no man will dare approach, through fear of consequences which may be all the more terrifying because of their unknown character.

THE remarks of Engineer-in-Chief Melville, made at the recent annual meeting of the New England Society of Naval Engineers, and published in the issue of *The Engineer* (New York) of March 17, contain much that is of especial interest in view of the fact that the subject of premium allowances to contractors has been so freely discussed and criticised of late. It is not infrequently supposed that the premium system has caused many of the new warships to cost more than would have been the case had the premium system not been adopted, but Mr. Melville shows conclusively that such is not the case, and cites the fact that, when the proposals for the *Detroit*, the *Montgomery*, and the *Marblehead* were first sent out, the bids were all in excess of the appropriations, the required speed being 18 knots. When the speed limit was reduced to 17 knots, the reduction in the bids not only enabled the vessels to be built within the appropriation, but even allowed the premiums to be included, for a sum less than the original lowest bid when the speed was placed at 18 knots. Mr. Melville also referred to the article of Mr. McFarland in the February issue of THE ENGINEERING MAGAZINE, upon the new cruiser *Columbia*, and to the pleasure he felt at the great success which had attended the use of the system of triple-screw propellers which he had adopted for that vessel, against the advice and opinions of many men of much experience who were disposed to look upon the plan as largely experimental. In this connection he took occasion to refer in a most gratifying manner to the great value of the services of Mr. Mattice and also of Mr. Hollis, and it is indeed a reflection upon the policy of our navy department that it should not be able to keep men of such value, both to their chief and to the department, in the government service when private concerns compete for them. Some day the fact that the very best ability should always be retained at its full market value for the service of the nation may be recognized and accepted, but, as it now appears, no man of the highest ability can long afford to remain in the government service when there are so many prizes to be had in private practice. It has been said abroad that in America government engineers are permitted to talk much more freely than in England, for example, and that such freedom is far more for the good of the service than the enforced silence which obtains there; and when we compare the instructive and valuable talk of Chief-Engineer Melville with the curious manner in which Mr. Macfarlane Gray was forbidden to speak upon a purely mechanical subject involving no government information, at a recent meeting of the Institution of Mechanical Engineers, we must express our appreciation of the wisdom of the policy of our government in this respect.

THE interesting and timely article in the last issue of this Magazine by Mr. Frank Richards, entitled "Precautionary Hints to Inventors," suggests renewed attention to what is probably one of the most valuable departments of the venerable Franklin Institute of the State of Pennsylvania. The committee on science and the arts, a large standing committee of mechanical specialists, exists for the sole purpose of examining and reporting upon any inventions which may be submitted to it, with the added advantage of the power to recommend awards of the various medals in charge of the Institute, should the merits of the case warrant such action. It is not too much to say that the work of this committee has been of inestimable value to those who have availed themselves of its services. When it is considered that it examines subjects with the same care as that given by expert specialists, making no charge for what otherwise would command a large fee, and that its approval or rejection is beyond criticism as regards prejudice or bias, the value of its services must be recognized. In many instances the unfavorable report of the committee has dissuaded either inventor or capitalist from certain loss or deception, while its approval and award in other instances has enabled financial assistance to be obtained, by sustaining claims which doubtless would have been received with incredulity if made upon the unsupported assertions of the enthusiastic inventor himself. Naturally such a committee is frequently called upon to examine subjects manifestly absurd in themselves and apparent as such upon inspection. While we believe that it has not yet followed the example of the French Academy in passing a resolution not to examine any new methods of squaring the circle, yet it undoubtedly reserves the privilege of rejecting such applications as are obviously unfit. At the same time, no one need hesitate to apply to the secretary of the Institute at Philadelphia to have his invention submitted for examination.

THE subject of synchronous vibrations is likely to receive more consideration in the future than it has in the past, since a thorough knowledge of all the elements which enter into this action may make it possible to reduce or possibly eliminate altogether the very objectionable vibrations which occur in steamships when the vibrations of the machinery are, so to speak, "in tune" with the hull. It is not unlike the old story of the fiddler who played the suspension bridge into a dangerous state of vibration; indeed, this principle obtains most practical recognition whenever a body of troops is ordered to break step when crossing a bridge. The excessive vibration which existed in one of the newer Atlantic liners was almost wholly removed by changing the speed of the engines, so that a cumulative vibration in the hull was no longer induced by the harmonizing strokes of the engines. A similar treatment might frequently be effective in cases where large buildings are found to vibrate to an undesirable extent by the action of heavy reciprocating machines, such as printing-presses and the like, and it seems possible that the use of some such instrument as Helmholtz's resonator might enable the "pitch" of a room, building, or even the hull of a vessel to be determined in advance to a sufficiently accurate degree to permit the speed of the machinery to be controlled beforehand, so as to reduce this reinforcement of vibrations to a minimum without involving radical changes after the entire plant is completed.

THE much discussed subject of transmission of power by belting is to have renewed attention given to it, under conditions that may yield a valuable addition to the present store of data, as a result of the proposed experimental investigations of the Société Industrielle du Nord de France in collaboration with the Institution of Mechanical Engineers. The latter society is to be represented by Professor Capper, of King's College, and the experiments, to be made at Lille, are to include a comparative investigation of the relative merits of ropes and belting for power-transmission. Accurate data upon this subject will be most welcome, as the present stock of information is hardly in a shape for satisfactory comparison, and more definite results should lead to a much wider use of rope-transmission if the proposed experiments confirm the conclusions derived from existing installations. It is to be hoped especially that these experiments will include comparative tests of the different systems of rope-transmission, such as the cyclic or reduplicated system already in extended use in the United States, as well as the so-called "ring" or circuit system introduced by Reuleaux, in which one endless rope traverses the entire circuit and returns to the primary source of motive-power. The advantages of these methods as compared with the use of a number of independent parallel ropes should appear in such a series of tests, as well as the relative value of each system as compared with belting, and the character of the tests as well as the final results will be looked for with great interest.

WHILE coal continues to be used as fuel for the generation of steam and the consequent source of motive-power the subject of smoke-production and prevention will remain a matter of contention, unless the entire method of combustion and application be modified. It undoubtedly is true that effectual devices for the prevention of smoke from soft coal have been produced, but the fact that the advantages accruing from their use have not so far appeared sufficient to induce owners voluntarily to adopt them suggests the propriety of further discussion of this somewhat well-worn subject. As a matter of fact, the production of smoke by a boiler-furnace appears to be a natural protest on the part of both boiler and furnace against the unreasonably close proximity of the highly-heated products of combustion and the comparatively cool boiler-surfaces; and the production of smoke under these conditions is about as natural a result as is the production of fog when the warm, moisture-laden atmosphere of the Gulf stream meets the chilling influence of the Arctic current off the banks of Newfoundland.

It long has been known that complete and efficient combustion can be effected only in furnaces from which all chilling influences have been removed, and the universal acceptance by builders of metallurgical furnaces of the principles enunciated by Siemens should indicate the true lines upon which, not "smoke-prevention" but absence of smoke-production, should be worked out. The use of gas-producers and the methods of using producer-gas are surely well-enough known to bear wider application than has yet been given, and the present practice of firing each boiler independently is not much less primitive than would be the use of separate gas-retorts for the production of illuminating-gas for each establishment. The introduction of electrical methods of distribution of power would make it altogether possible to have power-generating plants placed entirely outside the limits of our large cities, and enable vast batteries of boilers to be fired with smokeless gas, generated from the lowest grades of coal in independent producers; while the power developed in engines of highest efficiency and transmitted and subdivided by electricity might almost rival in cheapness that which is to be obtained from Niagara. That such a plan contains some of the elements of experiment cannot be denied, but that the uncertainties either of cost or of construction are greater than those of the control of the great cataract may well be doubted; and the entire elimination of the smoke problem would be included as what might perhaps be termed a negative by-product.

AT a recent meeting of the Engineers' Club of Philadelphia, the subject of machine-riveting was discussed in a most interesting manner, the more so as the members from whose experience valuable data were obtained included Mr. James Christie, of the Pencoyd Iron Works; Mr. Wilfred Lewis, of William Sellers & Co.; and Mr. Samuel Vauclain, of the Baldwin Locomotive Works. As might have been expected, the pressure per square inch of rivet-section varied greatly, ranging from 30,000 to 150,000 pounds for hot-riveting, or as high as 300,000 pounds for cold-riveting. The main point appeared to be the attainment of as high a pressure as practicable without causing a tension in the metal of the plate about the rivet-hole exceeding the elastic limit of the material.

IT is one of the prerogatives of success to have its failures overshadowed by the brilliancy of its greater achievements, and this is sometimes a mistaken cause for discouragement to those who are still struggling. If we could know more of other men's failures we would be more lenient with ourselves at times, and it is well to remember the reply of a veteran engineer to a young man who was commenting on the wide range and success of James Watt: "He was indeed a wonderful man, but you must remember we cannot look over his scrap-heap!"

THE YOUNG MECHANIC

Conducted by Frank Richards.

THE Editor of THE ENGINEERING MAGAZINE asks "Who should have a place in it if not The Young Mechanic?" and echo promptly shouts "The Young Mechanic." That settles it, and here we are. The question had to come and there could be no other answer to it. You can't run a locomotive without steam. The age we live in can't run without the young mechanic, and why should the magazine of the age? The sharp, clear echo in answer is characteristic and might have been expected. Prompt and confident is the style of the time. For assuredly now is the youth of the world. Youthful it is in every characteristic and attribute and habit. Lord Bacon elaborated the idea that "we are the ancients," because we know it all. Though Lord Bacon lived in a slow age he was too fast. We don't know it all. We are learning now as never before, and doing more every day, and piling up treasures of knowledge and experience for the ancients who are still far in our rear.

Others, in their day, have variously characterized the age of the world. Here is John Alden and his fair bride, "Priscilla, the Puritan maiden," riding in state upon a white bull.

"Like a picture it seemed of the primitive, pastoral ages;
Fresh with the youth of the world—"

Fresh with the infancy of the world, rather. Only now it is that we come to the full swing of lusty and all-conquering youth. The true bridal chariot for John Alden's bride to-day would be a tandem bicycle. Soon it will be a locomotive bicycle. Bye and bye (who knows?) it will be a flying-machine and a honeymoon above the clouds. It is no more safe to prophesy; you can't shoot far enough.

In all seriousness, let us say that if ever on earth the young mechanic had a chance now is his time, if he be found ready and worthy. Doubtless there are always those to be found hanging around who whine and lament that they were born too late, that the deeds are all done. The deeds must have been finished very suddenly, then. We have only to take a glance backward. No matter how far we look we see the same thing. Take any time, ten years, twenty-five years, a hundred years, and the nearer the time the greater has been the proportionate progress. The nearer the now the higher the speed, and to-day is the swiftest of all. It is for us to jump on while we may, and it is not to be supposed that things will go any slower after we get aboard.

IT is anything but a discouraging state of affairs that we note as we look out on the business of life with a thought of taking a hand in it. The speed is not a thing to discourage us as long as we have the means of going as fast as the rest. Speaking about how fast the mechanical world has been going, who knows, for instance, that the steam-engine, that was finished long ago, has been improved more in the last twenty-five years than in the sixty or seventy years before it. A pound of coal for power is worth three or four times as much on a steamship now as it was "before the war." We know that the Corliss engine is more than forty years old, and the Corliss name is the siren strain that still beguiles the wandering customer, but the "Corliss" engine now is not the engine of forty years ago.

The field of the mechanic has widened in every direction. The whole line of electrical machinery has arisen like magic. The building trades have been transformed. The iron-manufacturer and the machinist now put up the building, and the stone-cutter and the bricklayer are the decorative artists to finish it. The machine-shop has been reconstructed upon the modern lines. It turns out more and better work continually, but each shop has become a factory and each "machinist" is a specialist. The manual skill of the old chipper and filer is a story of a by-gone day.

> "Not for this
> Faint I, nor mourn nor murmur; other gifts
> Have followed, for such loss, I would believe,
> Abundant recompense.'

So we could not very well be "catching on" at a better time, unless it were a later time, and we can't afford to wait. It cannot fail to impress any one who will give it a moment's thought that the audience to be addressed by this department is a much larger one now than it could have commanded in any earlier day. This is a mechanical age all through. The range of mechanical interests covers every occupation. Those not engaged in actual mechanical pursuits are still so related to them as to make it needful that they keep informed along mechanical lines. Any one, whatever his occupation, is in these times at a decided disadvantage if he has not more or less mechanical knowledge, and, without any possible limitation, we may say that the more he has the better. At one time we might have found ourselves addressing a class of machinist and blacksmith apprentices, with a few carpenters and pattern-makers; but to-day the young mechanic is almost anybody who is interested in anything. The applications of machinery and of the products of machinery and of the methods of machinery cover all industries and interests. If we can succeed in offering information or suggestion of value to any, we know that it must therefore be of value to the many.

It may not be best to define very sharply what this department will undertake to do. Being assumed to be especially in sympathy with the hopes and aims of the young mechanic, it may find itself somewhat in the position in life of the young mechanic himself and have its course shaped more or less by the events of the time as they turn up, at the same time that it will be apt to do some of the turning-up for itself. If we get along as well as the young mechanic gets along in life we will have nothing to be ashamed of. When he first offers himself for a place where he may take hold and help to push along a little, the natural impulse and the general practice is to put him where he will do the least harm. Soon we find him making himself generally useful, then after awhile he becomes universally useful, and, before you know it, he is indispensable. We may hope to push the magazine along a little, and if, bye and bye, we find ourselves pulling it instead nobody will scold as long as everything goes. We hope to always respect the proprieties of the Magazine, but we may not forget that, to compensate for the ponderous dignity of the elephant, to him of all beasts it is permitted to wag his trunk as well as his tail.

As a dispenser of actual technical information we don't expect to figure very largely. If any dainty morsel come to our hand it shall go to swell the general store, but we must not be set up as a regularly-appointed caterer to the vast and clamorous call for mechanical provender. The whole of THE ENGINEERING MAGAZINE would not be large enough for a satisfactory exercise of that function. There be other storehouses vast enough, and filled with the riches of the fertile fields, and to them let any go that are in need. To the consummation of the most royal feast not the raw food alone is all that is needed. Right feeding is better than much feeding. We may perhaps help to prepare here and there a tempting dish of the materials that others have provided, but we shall remember always that, though the food be indispensable, so alike is appetite and digestion, and often the two latter are the more to be sought for and the more rarely found, and if we may help a little to stimulate the one or to promote the other we do exercise an office that is held among men to be more honorable, and more worthy of reward, than that of marketman or cook.

THIS winter has seen some brilliant and notable bicycle exhibitions. To these perhaps it may be attributed that we seem just now to have bicycle on the brain. Brain and bicycle are not a bad combination. Brain on the bicycle has done much for it.

The exhibitions spoken of must have opened the eyes of some of us to the rapid growth and the wide spread of the bicycle business, and when we remember how completely the bicycle belongs to the young, and especially to the young mechanic, it would have been a wonder if we had not been captivated, and if we had not been carried away an apology and an explanation would have been in order.

Who can realize how rapid has been the perfecting of the present bicycle? Who can realize for how short a time the present bicycle has been a possibility, not as an invention or, rather, a brilliant combination of inventions, but as a mechanical product? No matter how gifted an inventor may have been he would not have been able to produce the bicycle of to-day until to-day for lack of the material. The modern processes of steel production were to be invented with their means of cheaply, quickly, and accurately producing the precise metal for the special purpose, and always to be implicitly relied upon. How recent a production is the seamless steel tube that is literally, figuratively, and every way the backbone of the bicycle. It is said to be produced now by but two firms in the world and the process is supposed to be a secret, but there is little fear that the art of making it will ever be lost to the world. Yet the bicycle is entirely dependent upon this steel tubing for its present existence, and without this tubing an equally strong and trusty machine as the present could not be produced without adding a third to its weight; and lightness seems to be almost as necessary to a modern bicycle as to a balloon. And to-day we may seriously believe that the coming flying-machine is more likely to be evolved from the bicycle than from the balloon. Then, besides the special grades of steel for the several parts, and the wonderful tubing, a formidable line of special machinery and special processes of production have been devised in the interest of the bicycle, and these also have only been possible within a very few years. The perfect balls for the bearings are of quite recent growth; so also with regard to the chain, the pneumatic tires, and the others.

And, after all, the most striking thing about it is that we don't hear of any brilliant inventors that have done so many wonders in this one line. The fact is that so many have had a hand in it, each with his little suggestion, and here and there a more important one, that it has been impossible to particularize or to award special honors to any.

WE think that correspondence should be a valuable and attractive and helpful feature of this department. There are many things that we all want to know, and so many things that we don't know how to find out, and so many cases where we can help each other to find out and to spread the knowledge abroad. Then there are so many new things always coming up, and, other things being equal, anybody is as likely to strike them as anybody else, and if anybody does strike them everybody wants to hear of them, so please let us have them. Then a friendly word is a mighty power in the world, and of great help, to us young fellows especially; so if you have anything in that line don't hold it back and let it spoil. We will be glad to receive letters from any young person, not over ninety, upon any topic of interest to young mechanics. We think that on principle we ought not answer inquiries that do not provide for return postage. All other inquiries, not anonymous, will be answered, either by personal letter or through these pages. The identity of any writer will not be revealed unless permission is given.

IF we should seem sometimes to handle a correspondent roughly, no one is likely to get hurt. It will be only a playful shaking that will be good for his health. Now, here is a case. Some time ago "A Young Mechanic," so he signed himself, sent the following letter to one of the mechanical journals, and, curiously enough, we preserved it. "I like your paper," he says, "but I think it somewhat beyond the comprehension of young men such as I am. The illustrations of machinery and descriptions that do not name all the different parts are very hard to understand. You had a compound engine in the other day that, without more specific explanations, was of no use to me. Many expressions which young mechanics do not understand, such as shearing strain, and the like, should, in our interest, be made plain by diagrams. I think it would assist the paper and make it much more popular among young subscribers if all these things were carefully explained in an elementary manner."

Now, all that reads very nicely. Probably the dear fellow really thinks that he and those that he speaks for are abused individuals. It is really a mild and gentle case of martyrdom from his standpoint. But what is it that he really asks for? He wants Shakespeare in words of one syllable. Isn't that about the size of it? If you want a colossal monument of impudence it takes ignorance to build it. God's universe itself is not written so that all its lore is open to the pupils of its primary department. Much is always still unknown to stimulate to farther study. A periodical can't always time its march to the step of its hindmost reader. If you want to keep up with the procession it will be well to step out lively.

It is no use expecting to have every road made dead smooth and level for us. We are lucky often if we can only find a steep and rocky footpath through the woods. We can't have everything as easy as rolling off a log, or we will do nothing better than rolling off of logs. The world or the shop or the magazine is not run exclusively in our individual interest. We must not ask to have every description and explanation set to our precise level; we must level ourselves up to it. We must not expect explanations to explain what is already sufficiently explained over and over again elsewhere. Nobody wants to be continually doing what is already well done. All draw the line somewhere; and generally somebody is left on the wrong side of it.

Now this scolding that we seem to be dealing out is not generally deserved, and is not warranted by the facts of the case; but it certainly is not meant as a scolding for anybody. If we should get up and give somebody a scolding once, the difference would be evident enough. The difficult thing is often enough evaded through other motives than either indolence or cowardice. It is oftener that it is not attempted because the difficult thing is mistakenly thought to be the impossible thing. Even in the way of learning what we should learn, we often don't do what we might because we don't know how to get at it. Right along here is where a little correspondence and a little comparing of ideas might help us.

HABIT and tradition should not dominate the thought of the young mechanic. The ideas of the old mechanics are being knocked into all sorts of shapes in these days. One of the odd fellows was at the bicycle-show and he saw a bicycle operated by a train of bevel gears that seemed to please him because, as he expressed it, it got rid of the "unmechanical" sprocket wheel and chain, you know. Bless his dear old heart. There is no such thing as an unmechanical device except the device that wont work as well as it might. We all know now that there is no such a thing as absolute dirt, that dirt is only matter where we don't want it, and so there is nothing that may be termed unmechanical if it is the best known means for a given purpose. The chain and sprocket wheel on the bicycle is no more an unmechanical device than the locomotive-piston or the wheels of a watch. The old steam-engine mechanic may see lots of "unmechanical devices" in successful operation. Agricultural machinery abounds in them. The electrical devices are many of them "unmechanical." The fishing-pole on the trolley-car is enough to make an old school mechanic either laugh or groan and gnash his teeth, according to the state of his digestion. It is all right to the young mechanic. To him there is nothing unmechanical if it works well, and if it cannot be improved upon. When our bicycles come to be all driven by toothed gearing it may be time to call the chain and sprocket wheel unmechanical, and not until then.

But the term unmechanical if used as a

reproach cuts deeper than it seems to. It does not apply so much to the specific device as to the whole machine. The whole bicycle might as well be condemned as unmechanical as to condemn the sprocket wheel and chain. The bicycle of to-day is really a marvel of mechanical invention and much more so of constructive skill. It is of exquisite material beautifully blended and highly successful for the purpose intended. In these days the terms successful and unmechanical are incompatible. Fine workmanship carefully adapted to its object is as evident in the bicycle as in the locomotive. Think of a complete bicycle with pneumatic tires and capable of carrying a man and weighing twelve pounds. We might well call it an impossibility if it were not a fact.

FROM Prof. Thurston's glowing paper in the World's Fair number of this Magazine the item that seems most particularly to cling to us is that every man, woman, and child in the United States "consumes" 300 pounds of iron per year. It is not to be supposed that this consumption is very evenly distributed, not as evenly as the consumption of the food products, for instance. Of course infants consume less than adults, and perhaps, though this is more doubtful, women less than men, and some men much less than others, so that it is pretty certain that some of us consume as much as a ton a year. And when we remember how slowly iron is dissipated and destroyed, principally by wear or by rust, we must all our lives be accumulating a stock of iron that is in constant use for us, and we practically own, without the trouble of looking after them, lengths of steel rails, bridge-girders, beams of buildings, telegraph wires, and such things, and our stock goes on increasing all our lives. We all die intestate as to this property, and it goes to our heirs, who are the whole human race. While we live we can't well help feeling some sense of proprietorship in the world. More and more we have things in common whether we would will it so or not. We shall leave a big stock of old iron to be carried along by those who come after us. All the iron that the centuries just ahead of us have left are a few rusty swords and some rattling suits of armor.

WE are jogging along toward the end of the century. No, it was the old family horse and "the one-horse shay" that used to do the jogging. What became of the poor old horse when the shay went to pieces, "all at once and nothing first"? At any rate he is dead and gone now, and there is no more jogging, or joggling either, as we are borne along. We fairly glide along now, and so smoothly that it is hard to realize how fast we go. Still we have more than six-years-and-a-half before the end of the century. If we are wrong in our arithmetic some one will please to kindly correct us. At the rate we are going, if the pace is to be kept up, or continually accelerated as it has been all along, the distance still to be covered is a vast one. We expect that the century milestone will be a blazing pillar of glory and gratulation, and all who stand around it may be proud enough if they may think that they have had a hand in its illumination. Only there will not be any standing around. We will go whirling by it like a meteor. None of the centuries that we read of have taken much notice of their completion; what are we going to do about ours?

CURRENT TECHNICAL LITERATURE

Conducted by Nelson W. Perry, E. M.

"THE IRON FOUNDER" SUPPLEMENT. A COMPLETE Illustrated Exposition of the Art of Casting in Iron. By Simpson Bolland, Practical Molder and Manager of Foundries; Author of the "Iron Founder," etc. Illustrated. New York: John Wiley & Sons. [Cloth. 12mo. 400 p. $2.50.]

IT has happened in the history of the world that some of the most ancient, as well as most useful, arts haev been very slowly influenced and modified in their methods of practice by accumulating facts of experimental science and by progress in other arts. Pottery, glass-making, and metal-founding may be cited as examples. Yet, recently, these have received a marked impulse from the advances of science and of sister arts. In particular, iron-founding, heretofore uncertain in its results, has awakened to the possibilities afforded by modern machinery, the light which chemistry has thrown upon the substances affecting the character of iron, the aids this science has placed at command of the founder, and the improvement in products attainable by a system of easily-performed physical tests.

The literature of the iron-founder's art, as compared with others of more recent birth, is yet meager, and any good contribution to it will be welcome to progressive foundrymen. Emphatically this may be predicted of any book carefully written by a master of both theory and practice, who fully recognizes that the art has not realized its possibilities, and is earnestly striving to bring about such a realization.

Such an author is Mr. Bolland. Readers of this Magazine will remember a well-written and very interesting article published in the issue of June, 1893, wherein, in addition to an entertaining historical sketch of the art, lines on which future progress may be reasonably expected were pointed out, and they will be prepared to find in the treatise above named an instructive and valuable book. In this expectation they will not be disappointed, though they might, from its title alone, which announces the work as a "*complete* exposition of the art," be somewhat misled as to the exact character of the treatise. The discrepancy apparent in the title is rendered still more so in the first paragraph of the preface, which sets forth, substantially, that the purpose of the book is to complete "The Iron Founder," a previous and meritorious treatise by the same author, which, however, deals so much with molding that the author himself says "it is to be considered a molder's book." From this paragraph the reader might naturally suppose that molding would not occupy so much of the text in the supplement as it really does; yet this involves no inconsistency, as the molding chiefly discussed in this book is quite out of the common run, or such as the author has chosen to style "high class." The founding of statues in iron and bronze is treated in an extremely interesting chapter, the description of processes being made so lucid that any intelligent person, though unfamiliar with metal-founding, may easily gain a clear idea of the methods employed. It is impossible, however, in the space allowed for this review, to convey an adequate impression of the book by an attempt to single out such specimens as this; the comprehensive treatment of the subjects "malleable-iron castings," the "theory and practice of chilling castings," as illustrated in the manufacture of car-wheels, and "case-hardening cast-iron," are all that will thus be mentioned specially.

A better idea of the scope of the treatise will be gained by the statement that, so far as concerns processes, those not usual in the common run of foundry-work are discussed and described; while, with reference to tools and appliances, the whole field is exhaustively covered. What is said of pouring, flowing-off, and feeding cannot fail to be profitable reading to any iron-founder. If an expert, a perusal of this portion of the book will render more pronounced his estimate of the importance of care in the performance of this part of foundry-work, and, if yet a learner, he cannot afford to miss the opportunity of knowing what an able and experienced iron-founder has to say upon these subjects.

Probably most books offer a target for some criticism; and, after so warmly commending this book as a whole, it may be allowed to add that some pages near the end appear to be in the nature of padding, and that the index does not indicate as much painstaking as the general merit of the book deserves. Otherwise, it is a book containing up-to-date information indispensable to any iron-founder desirous of perfecting himself in his art, and valuable to all who are engaged in manufactures and constructive arts wherein cast-iron is an important material.

LEICESTER ALLEN.

ENGINEERING EDUCATION: BEING THE PROCEEDINGS OF Section E of the World's Engineering Congress held in Chicago, July 31-August 5, 1893. Published by the Society for the Promotion of Engineering Education as Volume I of their Proceedings. Edited by DeVolson Wood, Ira O. Baker, and J. B. Johnson. Columbia, Mo.: E. W. Stephens. [Cloth. 8vo. 342 p $2.50.]

THERE has been no more disputed question of late than how can we best equip the young for the conflict with life in later years. These discussions hitherto have been carried on usually through articles contributed to the various magazines or technical journals, or forensically in the meetings of technical or educational associations of more or less limited scope. At Chicago, the assemblages of the various congresses were more cosmopolitan, and the diverse views arising from experiences under widely-varying environments were brought more closely into contrast with one another, than they had been on any previous occasion, and not infrequently the exponents of those diverse views were men whose reputations entitled them to [illegible] respect. It is only by such exchange of ideas and their dispassionate discussion by competent champions that the greatest advances can be made. It was the cosmopolitan character of these assemblages that has given them their greatest importance, and the preservation in convenient form of the various ideas suggested for distribution and digestion at leisure among intelligent classes to which we must look for the production of the greatest amount of good as an ultimate result. The immediate result of the deliberations of Section E was the formation of a permanent organization for the promotion of engineering education, which has undertaken, as its first official step, the publication of the volume under review.

Those who are familiar with the subject know how great a revolution has taken place during the past twenty years in the ideas of what constitutes a liberal education. Scarcely two decades have passed since, by common consent, a liberal education, meaning by that a thoroughly classical course, was considered a prerequisite to the study of any of the learned professions. The former was considered a necessary preparation for the latter, and as a result the students in our professional schools were largely post-graduates. But the feeling gained ground rapidly that much of the time spent in this hitherto regarded preliminary course could be spent to much better advantage by devoting it at once to the study of those branches appertaining more directly to the profession in view. The pendulum swung the other way, and it is almost a rarity now to find a student in our technical schools who has completed an academical course in any of our reputable colleges. Then the question arose, and has been vigorously discussed, whether the manual training, field- or shop-practice should not even precede the attempt at mental instruction, whether the training of the hand should not precede the training of the mind, and, as a compromise, whether it would not be better that the two should go hand in hand. Educators are now beginning to realize that the pendulum has swung too far in this direction, and it is refreshing to note the tone of most of the papers, which is unmistakably in favor of *breadth* of education rather than specific instruction.

The first paper in this volume is one entitled "The Ideal Engineering Education," by William H. Burr, professor of civil engineering at the Columbia School of Mines. The key-note of this paper is found in the following expressions: "By means of a liberal training, the requisite powers of observation and a sound judgment are more symmetrically developed and far more accurately applied in consequence of truer conceptions of the object on which they are brought to bear and a correspondingly enhanced power of healthy assimilation is acquired. The broad cultivation, it matters little when or where it is obtained, is the only effectual corrective for that narrow and malformed excellence in some special direction, which, while it is certainly much better than no excellence at all, falls lamentably short of the vigorous and well-rounded product of the ideal education in engineering, The writer unhesitatingly places, therefore, as the first and fundamental requisite in the ideal education of young engineers, *a broad, liberal education in philosophy and arts.*"

Professor Palmer C. Ricketts, director of the Rensselaer Polytechnic Institute, in his paper on "Present Favorable and Unfavorable Tendencies in Engineering Education," expresses the unfavorable tendency of present methods, as follows: "It may be said in general that the engineer is not liberally educated. Beyond his profession his knowledge is not generally great. The writer believes the statement that the average man in any of the other professions is better informed on non-professional subjects to be a true one. The main reason is not hard to find. Very few of the young men entering our technical schools have had other than a rudimentary education. Very few indeed have had the advantage of an academic training. Their parents are too eager to get them at work. This is a mistake, and until the school of engineering is recognized as a post-graduate one it can hardly be expected that the engineer will take the rank among liberally-educated men to which his professional work justly entitles him."

George F. Swaine, professor of civil engineering in the Massachusetts Institute of Technology, in his "Comparison Between American and European Methods in Engineering Education," upheld what he called the American method for Americans and the continental method for Europeans. The former involved in its best form the co-education of the mind and hand, while the more characteristic feature of the latter was the great breadth of technical instruction givén and the employment of the lecture system almost to the exclusion of the laboratory method. He held that the lecture system was only of advantage to students of more mature minds than the average of those entering our technical schools, and, while it might be an admirable method for Germany, for instance, was a failure here. In conclusion he says: "The principal improvement in technical instruction in this country, however, must be looked for through an improvement in the lower or preparatory schools, and a raising of the standard of training and knowledge required for admission to our higher technical schools."

In the discussion of this paper Professor John Goodman (Yorkshire College, England) took the ground that the continental methods were entirely too technical, and that for this reason they, in a measure, unfitted the student for practical work.

In the discussion of the paper on "The Hydraulic Laboratory of the Massachusetts Institute of Technology," by Professor Dwight Porter, Professor Goodman called attention to a proposition made by Professor Lanza that seems worthy of consideration on account of its novelty, viz.: that the work at the engineering laboratories throughout the world should be arranged similarly to that of the different astronomical observatories. He recommends that each college take up some special class of work and do it as thoroughly as possible, and communicate the results to the others. His idea is that every one associated would have the benefit not only of his own observations and results but of those of the others. Such a plan would, of course, be entirely impracticable in our schools, although entirely practicable in institutions devoted to research only, the functions of the two being entirely different.

Some of the other papers read and discussed were on "Requirements in Mathematics for Engineering Education," by Professor Arthur N. Talbot, University of Illinois; "The Growth of American Mining Schools and their Relation to the Mining Industry," by Professor Samuel B. Christy, University of California; "The Equipment of Engineering Schools," by Professor Robert H. Thurston, Cornell University; "The Teaching of Graphical Methods in Engineering Colleges and Schools," by Professor H. S. Hele-Shaw, Harrison University College (Liverpool); "On Original Research by Students in Undergraduate Courses in Engineering, Especially Civil Engineering," by Professor Charles D. Marx, Leland Stanford Jr. University; "Training of Students in Technical Literary Work," by Professor Mansfield Merriman, Lehigh University; and "Methods of Studying Current Technical Literature," by Professor J. B. Johnson, Washington University (St. Louis).

We believe that this constitutes the most extensive symposium upon the subject of engineering education extant, and that it will furnish food for much thought among engineers in general and educators in particular.

A Pocket-Book of Marine Engineering Rules and Tables: For the Use of Marine Engineers, Naval Architects, Designers, and Draughtsmen, Superintendents, and all Engaged in the Design and Construction of Marine Machinery, Naval and Mercantile. By A. E. Seaton and H. M. Rounthwaite. With Diagrams. London: Charles Griffin & Co.; New York: D. Van Nostrand Co. [Leather. 16mo. 19-426 p. $3.]

SUCH a book has long been needed and desired by marine engineers, and the compilers of the above-named volume have shown an innate perception of what is likely to prove useful in a pocket-book for the use of this branch of the engineering profession. They certainly are unrivalled in the art of condensation. It would be difficult to suggest any topic connected with marine engineering concerning which this work supplies no information, and that in thorough shape and so arranged as to be easily found and not mixed up with general information. The excellent index at the end of the book adds to its utility. In a word, this is an exceedingly handy and efficient tool, possessed of which engineers will be saved many a wearisome calculation, or yet more wearisome hunt through various text-books and treatises. While they seem to have omitted nothing of special value to marine engineers, the compilers have avoided the introduction of extraneous matters, which would only make the volume bulky and its arrangement complex. It contains the most modern and approved practice. Steel has been dealt with as the material in general use and not an exceptional thing as heretofore, used only in high-class structures. The tables and weights, etc., are given fully for this material. Information and formulæ pertaining to light fast-running machinery has been elaborated and based on the most recent practice; also an excellent collection of data on screw propellers.

JOHN F. QUINN.

A Treatise on Public Health and its Application in Different European Countries. By Albert Palmberg, M.D. Translated from the French Edition and the Section on England Edited by Arthur Newsholme, M.D. London: Swan, Sonnenschein & Co.; New York: Macmillan & Co.

THIS translation of Dr. Palmberg's well-known treatise on public health may be heartily welcomed. It contains in succinct and compact form a resumé of the regulations affecting public health and sanitation in the chief countries and cities of Europe,—that is to say, in England, France, Belgium, Germany, Austria, Sweden, and Finland. It thus practically serves as a handbook to contemporary sanitary practice. The work has been prepared with the utmost care from extended personal researches; it has long enjoyed a European celebrity, and the present edition, which is the first in English, has been brought down closely to date. The book covers the widest range of topics, including everything that affects the public health and the sanitary conditions of living in city and country, from hospital regulations to those concerning buildings, from street-cleaning to the disposal of refuse. The subjects are treated briefly and concisely, as befits the wide range of topics and countries. Copious illustrations are used wherever needful. The longest section in the book is that devoted to England, which has been partly rewritten and wholly edited by Dr. Newsholme, the translator. This broader treatment of English sanitation was doubtless intended to make the book of greater immediate value to English readers, for whom the present translation was primarily designed. While not encroaching in any way upon the space devoted in the original to continental countries, it is perhaps to the latter rather than to the former that American readers will most incline. Some general review of comparative European sanitation has long been wanted in this country, and this want this book amply supplies. European countries, as a rule, go further in such matters than American communities have done, though the present tendency toward increasing the powers of our local boards of health and building departments is doing much to diminish this difference. Dr. Palmberg's work, if it has the circulation in America it unquestionably deserves, doubtless will do much to strengthen this tendency. We are glad to have an opportunity of heartily commending it, not only to the medical sanitarian, but to the lay reader whose familiarity with the questions treated in this book will add materially to the dissemination of correct knowledge on this most vital subject. B. F.

Eleventh Report of the State Mineralogist, California State Mining Bureau (First Biennial), for the two years ending September 15, 1892. Sacramento: State Printing office. [Cloth. 8vo. 612 p., illustrations and maps.]

THIS report, in print, differs widely from its original shape. As first prepared there were 2307 pages of manuscript, containing duplications and much that was irrelevant, in the judgment of the board of examiners, who declined to publish it entire at the state's expense. The governor in a message criticised it severely, saying that "people will not read long, tedious reports." The legislature then referred the manuscript to a specially appointed editor, Mr. Charles G. Yale, with instructions to abridge and condense the manuscript. Although greatly cut down, with the omission of much of the purely scientific and descriptive text, it is still a bulky, rambling, and by no means satisfactory report; unsystematic and incomplete in essential points of information, while diffuse in matters of little public interest. There is unquestionably much good reading in the report (and this no doubt would be true of some of the parts suppressed) but it lacks the prime requisite of such a publication—a concise, intelligible, general review of the state's mining industry for the period to be covered. The fault is one too common in our national and state official reports, resulting from a misconception of their proper scope and function, compelling the reader to sift for himself out of a mass of information which he does not want that which he is seeking for, or omitting it altogether. This last California mining report is by no means bad of its kind; it is neatly gotten up, with some taking illustrations, and should be serviceable to those who have the time to read it. But the kind is not to be approved.

ALBERT WILLIAMS, JR.

NEW BOOKS OF THE MONTH.

Anderson, William.=On the Conversion of Heat into Work. A Practical Handbook on Heat-Engines. Third edition. (The Specialist's Series.) London. [Cloth. 12mo. $2.]

Ball, Sir Robert Stawell.=The Story of the Sun. New York: Appleton. [Cloth. 8vo. $5.]

Ball, W. W. Rouse.=Short Account of the History of Mathematics. Second edition. New York: D. Van Nostrand Co. [Cloth. 8vo. $3.25.]

Bloxham, C. L.=Laboratory Teaching, or Progressive Exercises in Practical Chemistry. Sixth edition. London. [Cloth. 12mo. $2.60.]

Blumer, H.=The Home Life of the Ancient Greeks. Agriculture, trade, handicraft, etc. From the German, by Alice Zimmern. Illustrated. New York: Cassell Publishing Co. [Cloth. 12mo. 563 p. $2.]

Box, T.=Practical Treatise on the Strength of Materials, Including their Elasticity and Resistance to Impact. Third edition. New York: Spon & Chamberlain. [Cloth. 8vo. 525 p. $7.25.]

Briggs, W., and Bryan, G. R.=Elements of Coördinate Geometry. Part I.—The Equations and Properties of the Right Line and Circle. London. [Cloth. 8vo. $1.40.]

Burn, R. S.=Illustrated Drawing-Book for the Use of Schools, Students, and Artisans. New edition. London. [Cloth. 8vo. $1.]

Cook, W. W.=A Treatise on Stock and Stockholders, Bonds, Mortgages, and General Corporation Law, as Applicable to Railroad, Banking, Manufacturing and Other Corporations. Third edition. Two volumes. Chicago: Callaghan & Co. [Sheep. 8vo. 4000 p. $12.50.]

Crowley, T. S=The Law of Strikes, Lockouts, and Labor Organizations. Washington: W. H. Lowdermilk & Co. [Cloth. 16 mo. 390 p. 60 cents.]

Davis, J. P.=The Union Pacific Railway. A Study in Railway Politics, History, and Economies. Chicago: S. C. Criggs & Co. [Cloth. 8vo. 250 p., maps. $2.]

Demarest, T. F. C.=The Rise and Growth of Elevated Railroad Law. New York: Baker, Voorhis & Co. [Sheep. 8vo. 290 p. $3 50.]

Dickson, H. W.=Meteorology: The Elements of Weather and Climate. London. [Cloth. 8vo. $1.]

Donkin Bryan.=A Text-Book on Gas, Oil, and Air Engines: or Internal Combustion Motors without Boiler. London. 1894. [Cloth. 8vo. $6.50.]

Draper, C. H.=Heat and the Principles of Thermodynamics. With many illustrations and numerical examples. London. [Cloth. 8vo. $1.80.]

Foundations of the Molecular Theory: Papers and Extracts by John Dalton, Joseph Louis, Gay-Lussac, and Amadeo Avogadro, 1808–1811. (Alembic Club Reprints No. 4.) London. [Cloth. 8vo. 60 cents.]

Garnier, R. M.=History of the English Landed Interest, Its Customs, Laws, Agriculture. Vol. II. New York: Macmillan & Co. [Cloth. 8vo. 564 p. $3.50.]

Hickson, Sydney J.=The Fauna of the Deep Sea. (Modern Science Series, No. 60.) New York: Appleton. [Cloth. 9–169 p. $1.]

Hill, W.=The First Stages of the Tariff Policy of the United States. Baltimore: American Economic Association. [Paper. 8vo. 160 p. 15 cents.]

Holmes, G. K.=The Peons of the South. Philadelphia: American Academy of Political and Social Science. [Paper. 8vo. 140 p. 15 cents.]

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THE
ENGINEERING MAGAZINE
VOL. VII. MAY, 1894. NO. 2.

AMERICA'S NEED OF WIDER MARKETS.

By Hawthorne Hill.

THE most striking feature in the history of the United States has been their development, from a group of English colonies intended as a source of food for the parent nation and an outlet for the surplus from her factories, into a manufacturing country of the first importance. It was a notable address which Sir James Kitson, Bart., as president of the British Iron and Steel Institute, delivered at the opening of the session of that body in October, 1890, for the reason that it contained the first public acknowledgment, from an eminent English source, that the honor of first place in iron-production had passed from Great Britain—perhaps for all time—to the United States. The speaker gracefully emphasized this triumph of the young republic by dwelling upon the prohibitive legislation of parliament by which iron-making was held in check in the colonies until they had attained their independence. Thus scarcely more than a century had been left to the new country in which to outstrip its oldest and strongest rival, not only in the amount of iron produced, but also in the extent of its consumption.

At the beginning of our independence England held, as she supposed, the key to the industry of cotton-manufacture. Certainly she held the machinery without which such manufacture could not be carried on in competition with her own mills, and parliament imposed heavy penalties for the exportation of machines or plans or models of them. But here, too, the law-makers were powerless to shape the channel for industrial progress. There is not room in this paper to trace the history of the manufacture of cotton goods on American soil, which has progressed steadily in accordance with the law defined by Adam Smith, that the natural place for the artisan is in the neighborhood of the producers of the food and of the raw material, where

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both would be cheaper than elsewhere. In the absence of more recent comparative statistics, it may be stated that while the amount of cotton consumed in English factories between 1833 and 1878 increased five-fold, the increase in the United States between 1831 and 1880 was ninefold.*

Iron-making is mentioned here because the industry is universally rated as of the first importance, and cotton because it represents one of England's boasted leading industries and one which, on both sides of the Atlantic, has been intimately connected with the development of the modern factory system. But these are by no means the only lines in which American manufacturers have made their mark. It has come to be admitted that the United States are able to manufacture goods of any character for which an important home demand exists. Welsh tinplaters no longer comfort themselves by the thought that climatic conditions in America will prevent competition with them here, and Sheffield cutlers have ceased to boast that their inherited skill, coming down through many generations from their ancient guilds, will give them a permanent advantage. It is no longer absurd to talk about the introduction into America of manufactures of any kind; no longer are the people here dependent upon foreign mills, and least of all in the metal and mechanical trades.

As a further illustration of American progress, reference may be made to the superb new war-ships, which some English engineers and ship-builders seriously thought, when congress ordered their construction, would have to be supplied from the other side of the Atlantic. Even when the hulls were under way, Englishmen still contended that the engines and armament would have to be imported. Yet the ships so far completed are without a superior in any other country, though designed by Americans—and in some cases at variance with the best European practice—and built of American material by American labor. Thus is marked a wonderful advance from the conditions of a half-century ago, when Henry C. Carey, writing of American industries, said: "In 1842 we produced about 200,000 tons of iron, not a ton of which could be made into railroad iron, for we had no machinery for the purpose."†

The lesson of all this is that American ingenuity has become adequate for supplying American needs. This much having been established, the coming pressing problem will lie in a different direction:

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* As illustrating the natural law of development of cotton-manufacture as to locality, we may note that, whereas in 1831 only .6 per cent. of the cotton spindles in America were found in the southern states—embracing the cotton-growing section—these states had in operation sixty years later 8 per cent. of the whole number. The development of the industry has since been more rapid there than in any other section. H. H.

† *The Plough, the Loom, and the Anvil*, October, 1852.

how shall we best utilize the facilities which have come into existence in the supplying of our wants? With existing mills and plants we could provide for a vast population in addition to our own. It is scarcely accurate to say that over-production has resulted, for when the demand in sight is met the production in most classes ceases, leaving the wheels idle and the workingmen without wages. Mr. James M. Swank informs me that during 1893 the production of iron from the blast-furnaces in the United States was not greater than 50 per cent. of their capacity.* In the valuable manufacturing statistics of Massachusetts for 1892 it is shown that, of 4473 manufacturing establishments covered by the report, only 696 were worked to their full capacity, and that for the whole number the production amounted to only 69 per cent. of the capacity of the mills. These figures are not due alone to any temporary conditions; there has been no year for a great while in which a largely-increased production could not have been attained if a market had existed for the goods.

The industrial demand of the day is for markets abroad. The whole people are awaking to it, for the interdependence of interests is such that the legitimate profits of any industry add to the prosperity of all. We have not reached such a situation—but we are becoming able to appreciate it—as led Lord Dufferin to declare before the London chamber of commerce that, if existing political relations in India were disturbed, "there is not a cottage in Great Britain—at all events in the manufacturing districts—which would not be made to feel the disastrous consequences." The question of foreign markets has not hitherto appealed to American manufacturers generally, for the reason that they have had at home, as they still have, an unrivalled market for nearly every conceivable product of industry. To no other quarter of the world have the manufacturers and artisans of Europe turned more longingly than to the United States. The development of our trans-Mississippian wastes into populous and wealthy states, with immense cities and great railways, has been alone a greater achievement than the most extensive colonization work of any European country. It was natural that the intelligent, progressive, prosperous classes in the west should appeal more strongly to New England manufacturers than half-clad tribes in Africa, for instance,—with wants for manufactures yet to be created, with a language strange to us, living in countries almost inaccessible. Neither England nor Germany to-day would be so largely interested in the dark continent had North America continued to depend upon foreign manufacturers.

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* Mr. Swank, who is general-manager of the American Iron and Steel Association, writes: "The production of pig-iron in this country in 1893 was 7,124,502 gross tons. The capacity of our furnaces in 1892 was 14,550,708 gross tons. This capacity has not since been reduced, but has probably been slightly increased."

The first Cornelius Vanderbilt read the trend of events aright when he deserted the Atlantic shipping trade and turned his attention to railway extension, as a stepping-stone to vast development in his own country, and other American capitalists emulated his example. There was no lack of enterprise there, no neglect of opportunities, no want of judgment on the whole. On the contrary, development at home, serving to make of the United States a homogeneous nation, solidifying their interests or making them interdependent, and accumulating a reserve of capital in safe fields, has strengthened the country and fitted it now to enter the lists of international trade as a competitor worthy of respect.

This new departure in trade, however, demands a new course of training, as it were. Too many of us do not even know where "the markets of the world" are, apart from such centers as New York and Chicago and Denver. The character of foreign peoples, their languages, and their peculiarities of taste or customs are all a sealed book to us, even when they occupy portions of our own continent. There is perhaps no maker of wooden shoes in the remotest hamlet of Europe who does not know that his wares are not suited to the United States, but the shipment on a venture of refrigerators from this country to points on the equator, where ice is unknown, has been undertaken as a piece of good business. A United States consul at a small seaport in Brazil, who was asked by his government to report whether he had seen any American files in that country, replied that he had, but that the only use the people had found for files was to drive them into a wall for hat-pegs, or something of the kind. Doubtless the manufacturers of these goods, and of many others which have been shipped to Spanish America from our country, are now convinced that it would be a waste of time to try again to sell to people so ignorant. It might be well, as a first step, to learn on whose side the greater ignorance lies.

The most amazing mistake of all is the idea that the congress at Washington can legislate our products into the hands of buyers abroad who may not even know that we have a congress, and without any effort on the part of the producers. Robert J. Walker, coming from an agricultural state to the treasury portfolio in 1845, was much impressed with the idea of legislation to extend the exports of farm-products. In his official estimates he predicted an annual increase in such exports of almost 50 per cent. per year. The fact was that the American exports of articles of food, under the policy he advocated, declined steadily in value from $68,000,000, in 1846–47, to $21,948,000, in 1850–51. We have been scarcely more successful in legislating manufactures into the export column. Under section 3 of the McKinley bill the president of the United States entered into reciprocal arrangements with various countries, whereby such tariff concessions were secured in our behalf as to alarm certain English manufacturers, and to lead to a demand in parliament that the interests of Englishmen be similarly looked out for. Whether any increased efforts on the part of American exporters followed the "reciprocity" arrangement is not known, but the following official figures show that no remarkable increase has been made in the values of United States manufactures shipped to the countries involved :

	1889.	1893
Agricultural implements	$ 127,331	$ 188,188
Machinery not otherwise specified	1,733,404	3,682,830
Railway-cars	410,905	615,757
Car-wheels	18,587	27,807
Railway iron	22,768	351,447
Steam-engines	308,349	1,028,947
Cutlery, saws, and tools	513,778	729,997
Firearms	393,258	227,844
Nails and spikes	140,746	212,846
Wire	298,772	684,310
Other iron products	178,359	363,256
Cotton goods	2,763,357	3,465,748
Leather goods	526,360	473,586
India-rubber goods	92,418	118,475

It probably would be found that the increase in any of the items in this table was not accompanied by a falling-off in European exports to the "reciprocity countries," but that it figured in the general increase in the commerce of those countries.

The secret of the success of England, France, and Germany in selling goods abroad has been in their study of the countries to be supplied and in establishing and maintaining close relations with them. This subject has been capably treated by Mr. E. L. Baker, the United States consul at Buenos Ayres, who reports * that there have been English houses doing business on the River Plate for upwards of a century. They have made such good use of their opportunities that the United Kingdom has control, in large part, of the Argentine trade. But there is also in Buenos Ayres a French colony of more than 20,000 people, all engaged in trade or business of some kind, and there are some 15,000 or 20,000 Germans, with a trade beginning to assume considerable proportions. At the same time, says Consul Baker, "there are not a hundred citizens of the United States in the entire country ; and of these not twenty-five are engaged in American commercial business, and only one or two in the importation of American commercial goods." No sooner is any new want manifested by the people of the country than Europeans are ready with their offers,—

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*Reports from Consuls of the United States, No. 163, April, 1894.

probably with goods in stock, or with European shipping facilities for ordering them speedily and European banking facilities for the handling of bills of exchange. There are no fewer than five British banks in Buenos Ayres alone. The position of the United States in many branches of South American trade is better illustrated by the case of a New York firm who received a cable order from Rio de Janeiro, and who answered that the goods could not be shipped before the return of a vessel which happened at the moment to be discharging cargo at the latter port. The Brazilian repeated his order by cable to London, and it would not be strange if he never attempted again to buy anything in the United States.

It is not here implied that there are not to-day in the United States manufacturers and merchants who are as enterprising and as successful in securing foreign trade as any of their competitors in Europe. There are firms which have laid the foundations of immense fortunes in the Spanish-American and Australian trade, particularly. Even in the Argentine figures there is encouragement, as will be seen from the following comparison (for 1892) of the share of leading nations in the commerce of that country, it being kept in mind how Americans are handicapped by the lack of ships, of banking connections, and of a resident American population:

Great Britain	$55,556,005
France	36,863,962
Germany	27,311,616
Belgium	21,319,265
United States	12,208,037

The independent, assertive, enterprising American character cannot fail to make its impress upon foreign commerce, just as it has succeeded in wresting the American markets from foreign control, when it is once fully understood that the route to new fields of trade does not lie through the halls of congress at Washington.

It is a mistake to assume that because England, for instance, leads in the export trade with any part of the world, it is useless for others to venture into the same field. As well might Americans once have hesitated to build locomotives or war-ships. Already American railway equipment has been sold readily in competition with the English in South America, while important outfits of our mining machinery have been ordered from Asia in preference to that of European production. Indeed, the whole question of competition with European manufacturers—apart from any question of superiority, one way or the other, of products—is one which offers encouragement to Americans. It must be considered that the United States, with an immense population of a high average purchasing-power, can continue to absorb greater quantities of manufactured products than any European country in new developments—as in mining, bridge-work, electrical plant, etc. —and in improving existing railway equipment, rebuilding growing cities, and replenishing the machinery on farms, many of which sources of demand are better supplied in Europe than here. Consequently, our factories and their wage-earners are less dependent to-day than those of any other great manufacturing country on the export trade. The latter, instead of being their mainstay, is only a welcome addition to an already paying business. The factories, being maintained at a high grade of efficiency to supply an immense home demand, are in a good position for filling orders from abroad without the necessity for new equipment.

Our sale of surplus products, naturally, will be in newer and undeveloped countries rather than in the countries of Europe,—which began before we did to suffer from over-production,—except in patented specialties, which will sell purely on their merits, and such raw materials as cannot be bought elsewhere. It is not at their homes, but in common markets, that we must wage competition with Europeans. In this connection it might be of interest to study some of the international complications which Americans are apt to dismiss hastily as war rumors, due to the maintenance of big armies, but which often are the outgrowth of careful scheming to secure or retain markets, the loss of which might reduce the proud England of to-day to a second-rate power, as Spain and Portugal, former rulers of the seas, were reduced under like circumstances.

Mr. Holt S. Hallett contributes to the *Nineteenth Century** a notable article on "Western Nations and Eastern Markets," in which he asserts that the alliance between France and Russia, supposed to have been concluded last year, is as serious a menace to Great Britain's immense Indian empire and to her markets in the far east as it is to the peace of Europe. Napoleon and Alexander I, as early as 1807, sought by a league with Persia to drive England out of India. Long before that the French were suspected of having instigated the king of Siam to dismiss the English traders from Bangkok, and altogether the French have been recognized as active rivals of England in the east. The recent absorption by France of eastern Siam has enlarged her base for further aggression on Siam and China (which is one of England's most valuable markets), while India holds itself on the defensive for an advance of Russia. Russia has a wonderful power of assimilating Asiatics into subjects of the czar, and China regards with fear the progress of the trans-Siberian railway, which is being built avowedly for military and political rather than commercial uses at present.

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* London, March, 1894.

France has also looked forward to the dismemberment of China, and to profiting thereby. Briefly, then, according to this writer, China, Japan, Siam, and England's Asian possessions—containing more than half the world's population, and the largest, richest, and most promising markets for English goods—are threatened by France and Russia to such an extent that British commercial intercourse with them will be crippled.

It must be understood that the British idea of developing these far eastern markets has involved extensive railway-building, since the seaboard and navigable rivers give access to only limited areas for commerce. Lines are now being pushed from the coast into the interior in all these countries, rendering them daily of more importance to England. India has become valuable as a market chiefly through the extension of its railway communication. The fears expressed by Mr. Hallett, that England's railway routes to India and China, existing or in prospect, may be blocked by the aggression of the rival great powers, lead him to a most pessimistic view of the future of British commerce, unless Her Majesty's government should succeed in protecting its eastern interests. One of his concluding paragraphs is significant: "If we lose our markets we lose our means of subsistence. With foreign competition hemming us in on every side; hostile tariffs barring us from our old markets; and *the knowledge that every bit of the world's surface which is not under the British flag or British protection is liable to be closed to our trade*, we are to do our utmost to safeguard and develop our commerce in the vast markets of the east." *

Whether or not Mr. Hallett's predictions may be well based, his views are shared by many others. Such considerations in part doubtless have prompted England to put under her protection as much as possible of Africa, with a view to developing future markets on that continent. If her commercial supremacy should be lost in eastern Asia—between which and the United States there is no barrier but the Pacific ocean—we ought to be in a position, having no political entanglements or rivalries, to make a strong bid for the trade of that part of the world.

For the present, however, the most promising field for extending the export trade of the United States is on American soil, in the countries to the south of us, in many of which undoubted development is taking place, in which peace and political stability are reasonably assured, and with which we are already on friendly terms. Every shipment of goods in that direction which has been made intelligently, and followed by intelligent effort, has served as an entering wedge for the introduction of North American products. There is a growing demand in the far south for such goods as our people are prepared to manufacture, while the products of that quarter are largely of a class which are needed here, and which do not compete with any of our home industries.

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*The italics in this paragraph are mine. The English writer, by the way, seeks to support his position by such facts as this: "Prices have fallen to such an extent that for twenty years the value of the yearly export of our [British] home produce has been practically stationary, and for the last few years actually decreasing, instead of steadily increasing in the same ratio as our population." H. H.

As for methods in the export trade, it may safely be taken for granted that what is being done successfully by one country can be done by another, just as Americans have demonstrated their ability to manufacture goods in any class that has been produced abroad. American disregard for precedent in dealing with political and industrial institutions, here on new soil and under novel conditions, may have been well enough, but in cultivating trade with other countries, perhaps much older than our own, it would be foolish to ignore the example of those who have already succeeded in this field, whether Americans or Europeans. To find what foreigners want, and for what they want it, and the differences between their tastes and those of our own country, is a work requiring study and application, involving travel and the special education of multitudes of our younger men. The manufacture of superior goods is not enough. Even low-priced goods will not give the key to the situation. The question, when our competitors are found selling goods in any market accessible to us, is "How is it done?" If our manufacturers are not ingenious enough to answer the question for themselves they may as well remain content with their home trade; no one is going to force the knowledge upon them.

ARCHITECTURAL EDUCATION FOR AMERICA.

III.—THE ENGLISH METHOD.

By R. W. Gibson.

WHAT is an architect? That part of the public which employs architects would describe him as a professional adviser and assistant in all matters pertaining to buildings—an executive officer whom they appoint to exercise authority and to perform duties of a practical, economic, and artistic nature.

Is this a correct definition? Or, is an architect a student of a traditional cult whose mission it is to engraft upon the outgrowth of a practical world as much as he can of his archæological flora, even at the sacrifice of his client's opinions and purse; and to maintain an academic standard and dogma, even if previous similar dogmas have been abandoned?

This latter definition is really the one toward which much academic training tends. It is quite naturally so. Schools must be conducted by men who devote more time to the traditional art than to the practical. They build up for themselves standards and precedents and methods out of touch with the greater world for which they primarily exist.

Art is a reality, and is greater and higher than her devotees have ever claimed. But she should be our familiar friend, visible in every work of every day, and therefore should descend to every-day matters. It is necessary that art in architecture should be ready and able for the opportunities which daily occur, rather than for the task of maintaining ideals of infrequent and debatable value.

The English system of architectural education, while it leaves much to be desired, has a great advantage in this regard. Its fundamental principle is that academic study shall be subordinated to, and coincident with, actual work under a practising architect. The student thus learns at one time the purpose and the profit of his studies. His wants, and the satisfaction of them, occur to him simultaneously.

There are possibilities in this system that have not yet been fully developed, partly because the academic course has even here maintained until recently too separate an attitude. Let us examine it in detail. The origin of the system is the apprenticeship, which sprang from the guilds in which all skill was organized in the middle ages. In Elizabethan times it was unlawful to follow any occupation without first serving an apprenticeship. The articles of apprenticeship were not only a promise to teach, but also an admission to a close corporation, with its privileges to practise. But these restraining laws, after much curtailing, were finally repealed in the reign of George III, so that now the privileges are artificial or private, and largely fictitious. Still the form of apprenticeship survives for its other real advantages, and the architect in English practice who has not passed through it is rare. It is usual for a pupil to engage with a master for three years, paying a premium of about 200 guineas, part of which is returned as salary in the latter part of his term.

But the many branches of study which have no place in the office routine of an apprentice have to be provided for. These at first very appropriately fell to the care of those societies which had been constituted for the conservation of the higher interests of the profession. The Royal Institute of British Architects and the Royal Academy of Arts have long given some facilities to students in these departments, and, in a more general way, the National Art Training School (at South Kensington, with numerous branches) has assisted. The universities and colleges have also contributed in various courses towards the same ends, and more recently the new London county council has included technical education in its progressive programs. But with all of these independent and scattered opportunities it could hardly be claimed that there was a system until the Architectural Association, by patient, continued effort, established a real school of architecture in comprehensive form, and secured harmonious action with some of the other older societies.

This association, constituted in 1847, was, and is, one relying upon coöperative effort of the students themselves. More liberally inspired, more accessible, and more practical than the senior bodies, it speedily became more useful. Its early efforts, chiefly in freely-contributed papers and in classes for mutual criticism, reached a valuable efficiency twenty years ago; and lately have developed into a systematic four-years' course intended to supplement the training acquired in the offices where members are engaged as pupils or assistants. The fees are moderate—10 guineas each session—and the work is almost entirely arranged for evenings. The list of lecturers and instructors includes the most able men of the time, and the old system of honorary "visitors" (seniors as critics) is retained.

There are certificates, medals, and prizes, and beyond these the course leads up to that of the Royal Academy of Arts with its further lectures, medals, and scholarships, and to the examinations and graduation in the Royal Institute of British Architects, which is the legitimate "final" of any architectural training in England. The passing of this examination, it is resolved, after 1894 shall be a preliminary condition to membership in the Institute. But apart from this fact the Institute examinations are really the natural sequel to the Association course, and, with the present cordial relationship between the two societies, they may be considered as forming a single system.

The curriculum at Kings College, London, spreads over three years a course of study also intended to lead up to the Institute examinations, arranged in three terms for the year, and occupying practically all the time of the student instead of only the evenings. It is claimed, however, that this work is intended to prepare students for admission to an office or to supplement their work there. But three years is a long time for the student in architecture to double by taking successively what he can do simultaneously. It is not surprising, therefore, that the Institute itself sustains, by quoting in its journal (October, 1892), the opinion that "the course of education now provided by the Association is substantially that most suited to the majority of students." It is gratifying too to note the following passage in the same place:

> The constant aim of all Association endeavors is to develop originality and individuality in its members, and the fact that its government, and to a large extent its actual tuition, is in the hands of comparatively young men, is a complete safeguard against any tendency to rigidity or formality, in either its methods or its teaching.

A student of architecture in England has abundant opportunity for systematic work. After a good general education he may commence with the Institute "preliminary," by which he enters himself as a probationer, and a trial term in an office. Then (being articled probably, in deference to time-honored custom) he may enter the Association, and take up the curriculum as a four-years' course requiring four evenings a week for eight months of each year,—one evening at lecture, or class, one in preparation for the same, and two evenings in the studio. He may, of course, spread the work over a longer period, or perhaps shorten it somewhat. After two years he may pass the intermediate examination, the examination being divided in order to avoid the strain and "cramming" encouraged by one long-continued ordeal. After four years he may take the "final" or qualifying examination. All this time he has been at regular work as pupil or "improver" in an architect's office. He will then usually make a change to some other office in a more responsible position; perhaps he will continue his Association work; possibly it is not completed, or the examination not successfully passed. If he has still the energy and pluck for evening work he may enter the Royal Academy, of which the Architectural School is artistic only (omitting science as such). The course is valuable—the lectures, and the practice of more advanced design especially—but the greater number of students there have in mind the medals and scholarships. The principal prize is the gold medal and foreign traveling studentship, which, together, are awarded every second year. The course—probation, lower school, and upper school—takes five years. It would be very much better if this course could be brought into more harmonious working with the Association and Institute programs, so as to permit of its being taken by the same students without the excessive waste of time. At present it does not form a necessary part of the unified scheme, which may be called the English system of architectural education, and which may be summarized as first, the office work ; second, the Association classes ; and third, the R. I. B. A. examination.

The best results of the system above described are yet to be seen. The architecture of to-day is being done by men who enjoyed only the less perfect beginnings of the system, when it was building up by their experiences. There are great possibilities in it. It should turn out practical architects. It avoids, to some extent, that pitfall of youth, the self-satisfied period of collegiate graduation, from which the reaction upon entry into the real world is so demoralizing. It keeps the actual living work and the revered traditions in touch without allowing either to extinguish the other. It is above all others a practical system, having grown out of necessities, and not out of theories. To Americans it promises better results than any other, because of its coöperative, decentralized methods. The examining power is the only one claiming authority ; all the educational routine is free for self-organization.

But the student should not be required to sink his whole individuality in the routine of a course. He will have his favorite special subjects, and should be allowed some time and opportunity for them, as well as for the ordinary social and intellectual pursuits of youth. The whole course of routine work should not necessarily exceed three years. It should be possible for the student to complete his collegiate education before entering the strictly technical course, and still complete the latter before that age at which it is necessary for a man to begin his individual career. Allowing a year for travel, and for the process of establishment, this would carry one to the age of twenty-four or twenty-five,—none too early for the commencement of a professional life.

While reducing the time demanded, further improvement might be made in the character and scope of the examinations. The tests should be more such as prevail in actual practice. A thoroughly competent man may—nay does—look upon a test of the usual kind with dislike and distrust, simply because of its pedantic and unreal demands. This should not be. All such examinations should represent as nearly as possible the conditions of actual work. It may be added that the standard for graduation should not be so high as to be discouraging. If it is more difficult than the tests of actual work, it cannot be enforced. Conducted in such a way it seems that this system of standard examinations by a central body with authority, following a course of study under independent educating institutions in which variety may be permitted, is the most promising method of architectural education.

IV.—AN OUTSIDER'S VIEW.

By Barr Ferree.

ARCHITECTURAL education is the foundation of good architecture. The time when an untrained architect could make his mark in America, financially or artistically, has long since passed away. The question is not, "Shall the architect be educated?" but "How shall he be educated?"

First of all, the American architect must be trained with a view to his work in America. In itself this is a broader task than a single man can well hope to accomplish in a lifetime. The conditions of American life—the climate, the materials, the manner of living—are so varied and complex, and are so constantly changing and profiting by new inventions and devices, as to render the task of a busy practising architect a work of enormous complexity and magnitude. The wise architect leaves the details of this to skilled specialists, but he must be familiar with everything that enters into the construction of his buildings, and be entirely up with the latest methods. Most of this knowledge must come from self-training after the active duties of the professional career have been entered upon, but the preliminary studies must have all these complex circumstances in view or fail in the first elements of practicability.

For architecture is a practical art, and is concerned with the physical well-being of mankind. We may ornament our buildings with the richest flower of an artistic fancy, if we choose and if we can obtain a client who will pay for it, but at the bottom there is the fundamental fact that the building is to serve some useful end: it is to be used for some purpose, it is to have a definite, usable value. At the very beginning the architect's education must recognize this point. He does not enter the profession to create beautiful things on paper, to devise fanciful structures, or to make ornamental designs,—perhaps good enough in themselves but most unlikely of execution. His actual work, once he sits down to practise, is the designing of structures more or less utilitarian in purport, whose design is limited by countless conditions of cost, of site, and of other elements that may not appear in the architectural text-books, but which strongly affect his work.

And from this there can be no mistaking the second point: that the architect's education must be conducted on a system that keeps the ultimate end well in view. Architectural training is a technical training, and under no circumstances should it be entered upon until the student has had the advantages of a thorough preliminary schooling. Being of this nature, it must have the student's life work in view. But it should do more than that. Not only are the final practical ends of the system to be maintained, but the student must have opportunities to gain a general knowledge of architectural history, forms, and methods which it is impossible to gain in the busy work of an office, and which, unless thoroughly grounded at the outset, may be forgotten in the turmoil and bustle of actual practice.

This is the vital point, and here, perhaps quicker than elsewhere, the advocates of special systems of architectural training will most widely differ. If, we are asked, the educational period is the only opportunity the architect will have to study the theory of his profession, should not his whole time be given up to such study, and the unavoidable practical work, which will come only too soon the moment an office is opened, be left for the future? As a matter of fact, architectural education is to provide that general technical training that cannot be obtained elsewhere. It would seem, therefore, on some grounds, eminently proper to give up this preliminary time to such study. But, in fact, the question is not so broad as this; the real question is not how much time shall be given to theoretical study, but what theory shall be studied, and how.

A theoretical study that ignores the practical application of the theory quite fails of the elementary purpose of training. This is especially true of architecture, which is entirely practical in its nature and expression. Theory should enter into the architect's education only in so far as it has a direct bearing upon practical problems. An education that stuffs a young man's head with theory, without showing him its application to his future work, is distinctly wanting in the practicability upon which all technical training should properly be based, and with which all his future work is concerned.

This brings me to another point, that the training of the American architect should be based upon American conditions. An architect may be filled with architectural theory without being able to apply it to the exacting conditions of American life. An education good for one land may not be good for another. Because an academic system answers sufficiently well, from the French standpoint, for France, it is a wholly unnecessary assumption that it will be equally successful in America, which is most distinctly and unequivocally unacademic.

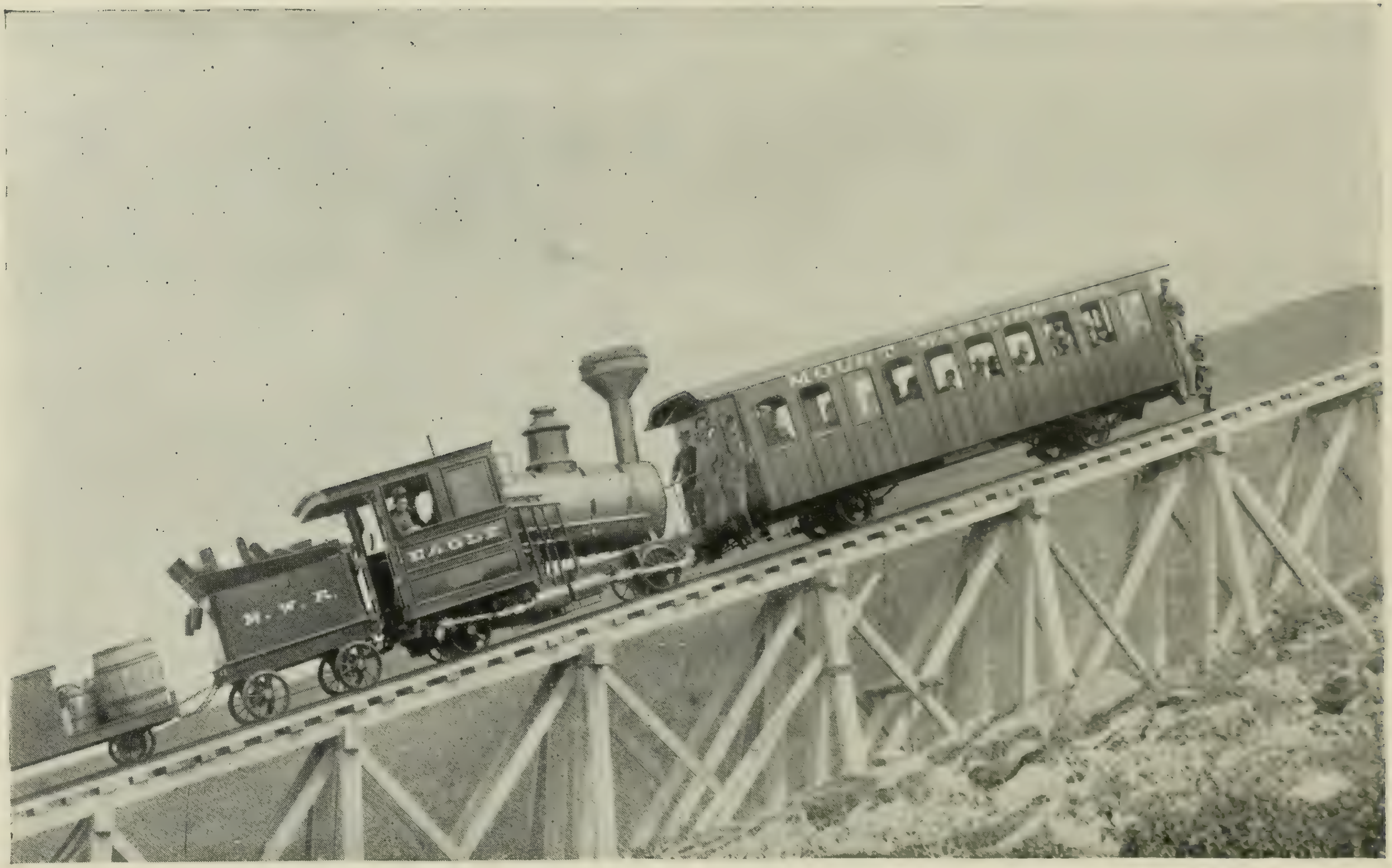
It is a pity that we have in America so few opportunities for the exercise of great artistic architectural talent. It is true we do not appear to have the talent to be exercised, but with more ample opportunities this might be righted. Architecture at any time and in any country is apt to be as good as the time and place can tolerate; certainly we can scarcely tolerate a higher grade of architecture than we have until the good of it and its value are appreciated by the general public, on whose patronage opportunities for good and bad work alike rest. Some day, perhaps, we may have an opportunity for producing the masterpieces that are the hope and dream of some architects. Meanwhile, it behooves us to do the best we can with what we have, to better it at every opportunity, to do all we can to hoist it out of the rut into which centuries of disuse have cast architecture. Little enough of what we have is inspiring,—so little and so unartistic that there is no wonder that those trained in a broad, theoretical field should look with regret upon early times of theoretical performances, and sigh over the disgusting little things that modern commercial necessities condemn one to practise with.

But that is what we have; why then try for something that cannot be obtained? The ideal modern American architect—I am not concerned with any other—is he who does the best with the opportunities given to him. American architecture, as no other architecture is or was, is dominated to-day by commercialism. It may be wrong that this is so, but it is an unquestioned fact. Any architectural training that ignores this hampers the young architect, and directly retards the bettering of American architecture, by providing an element of dissatisfaction with what is that is wholly uncalled for and is immediately harmful in its results. The American architect is called upon to solve certain conditions; his business is to solve them in the best way and usually with the least expense. Commercialism runs through his work, which is successful only so far as it fulfills commercial requirements into which artistic conditions enter only to a minimum extent.

Commercialism in architecture does not fit in well with theory in architectural education; yet in itself it is only the current form of the word "practical." Once in a lifetime an architect may be called upon to design a palatial residence or hotel, a museum or state house or other public structure, that calls for the exercise of the finest artistic talent; but if this happen more than once it is exceptional. The bulk of the work of the modern American architect is what may be termed "common things,"—strictly utilitarian structures with a maximum of use and a minimum of art. If these "common things" are to be improved, if commercialism is to be rendered less commercial than the baldest treatment presupposes, we must begin at the beginning and train the architect with this end in view.

So far as I am aware, no system in America takes into account this phase of the question. Most of our architectural schools, as every one is aware, are modelled, in their strictly architectural teaching, upon the famous École des Beaux-Arts of Paris. With many of the principles taught in this school every thoughtful architect must heartily agree, being in themselves not school principles at all, but the fundamental elements on which good architecture has rested in all times and in all lands. It is a remarkable fact that a school man will always talk better than he works. He will astonish you with the breadth of his training—broad, not so much for his sojourn in Paris as for his own personal application ; he will amaze you by the correctness of his theory ; he will dazzle you by the brilliancy of his knowledge ; and then he will sit down and do the most preposterous things in design, simply because, with all his theory, his training, his brilliancy of thought, his power of expression, he has so wedded himself to certain forms and certain academic modes of expression as to be totally oblivious of their complete inapplicability to the necessities and exigencies of American architectural conditions.

How thoroughly this may be the case is well illustrated by the experience of one of the most promising and capable of the younger students at the Beaux-Arts. Prior to entering the French school he had been in practice in an American city, where he speedily won success by the readiness with which he solved the small average problems that come to every architect. After study at Paris he found himself quite unable to do what he had before done with so much ease and skill. Instead of small things he had learned to do great ones, and doubtless many years will be spent in endeavoring to secure the first large work that he has every reason to believe himself capable of doing. Personally, I should be glad to wish this gentleman the utmost success in the world, but his experience is most convincing evidence that the system of architectural education most in vogue in America is utterly at variance with the prevailing conditions and limitations of American life.



THE MT. WASHINGTON RAILROAD. THE PIONEER RACK INCLINE, COMPLETED IN 1869 BY SYLVESTER MARSH.

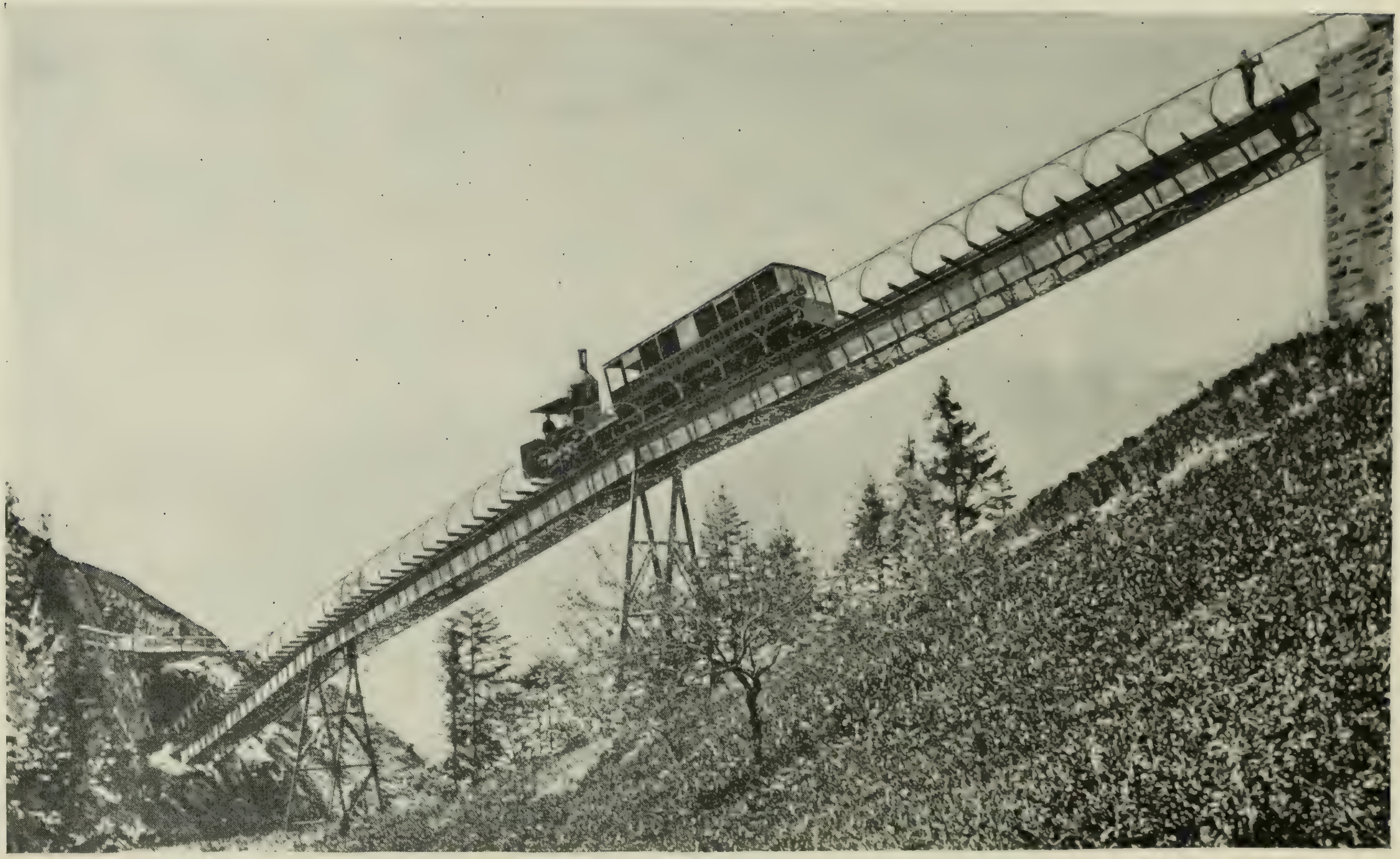
INCLINED RAILWAY SYSTEMS OF THE WORLD.

By Theodore C. Ives.

WHEN an obstruction is met with in the line of progress of any sort there are usually presented four alternatives: to go over, to go under or through, to get around, or to remain *in statu quo*, obstructed for all time. Nature has placed her obstacles to the progress of inland commerce in the form of the precipitous cliffs and massive undulations of the mountain-ranges which traverse the continents of the earth, and it is the various methods employed in overcoming these natural difficulties, according to the principle of the first alternative, "to go over," that this article will endeavor briefly to describe.

Primitive inland commerce grew and waxed strong on account of the facilities of interchange afforded by the many navigable streams, but was necessarily confined to their locality, and extended departures inland were always attended by great labor, risk, and loss of time. Hence, the growth of the river-towns and that wonderful fleet of steamers which once plied the waters of the Mississippi and its tributaries. Inland navigation was extended by the canal systems, but greatly restricted by sudden changes in the elevations of the country through which they were located, and a quick means of raising a boat from a lower to a higher level, that would obviate the tedious process of locking, became a necessity.

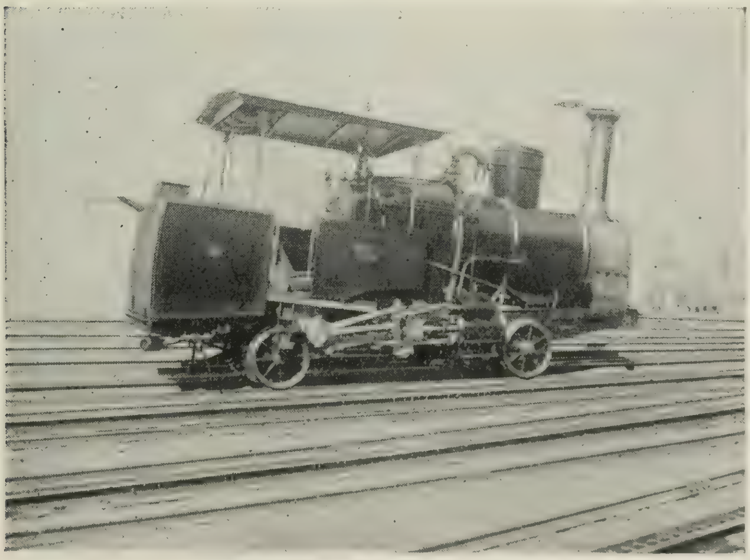
There are to be found to-day, on the old Morris and Essex canal, examples of the canal-boat inclines which at the time of their construction so greatly facilitated water transportation. A canal would seemingly terminate at the base of a hill, up which an inclined railway was constructed to the summit, where also terminated the canal of the upper level. The waters of the upper canal escaped through a sluice supported by a trestle which ran to the top of a tower constructed at the terminus of the lower canal; down this tower the water fell upon a water-wheel operating a winding drum; also at the end of the lower canal there was a great portable cradle on wheels. The boat to ascend entered this submerged cradle, and when all was secured, the water being admitted to the water wheel, the drum revolved, winding the chains or cables. Thus the cradle with its load would travel up the incline. Upon arriving at the summit the cradle was submerged in the upper canal, and, when liberated, the boat could sail calmly out of its curious carriage and proceed upon its way. With a boat going



THE VITZNAU-RIGI RACK ROAD, IN SWITZERLAND. TRAIN ASCENDING BRIDGE ABOVE THE TUNNEL.

ANOTHER VIEW OF THE VITZNAU-RIGI ROAD.

in the opposite direction this operation was reversed, and the boat, after entering the carriage and descending, could be safely floated into the canal of the lower level.

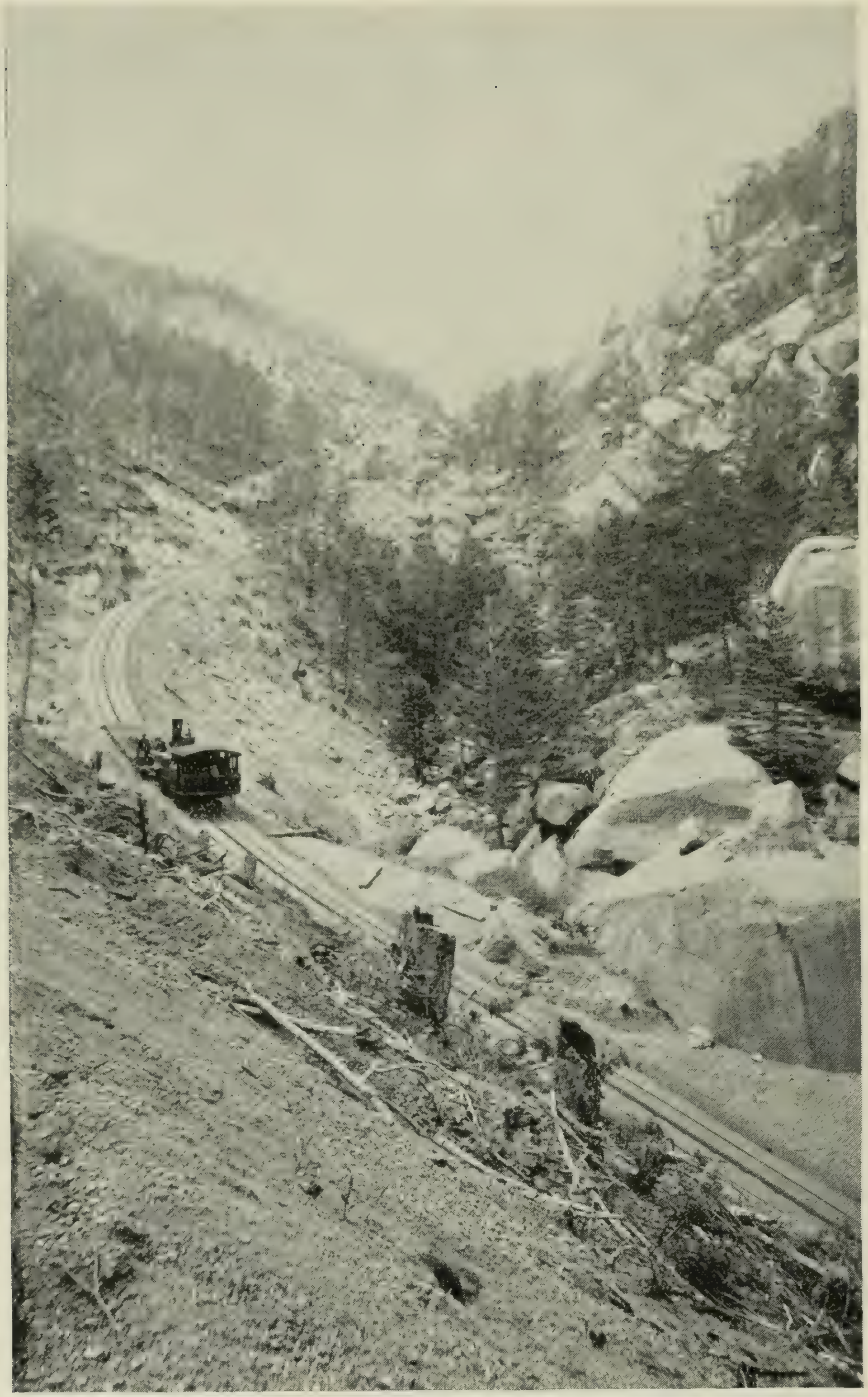


ENGINE USED ON THE RIGI ROAD.

[Locomotive with Horizontal Boiler.]

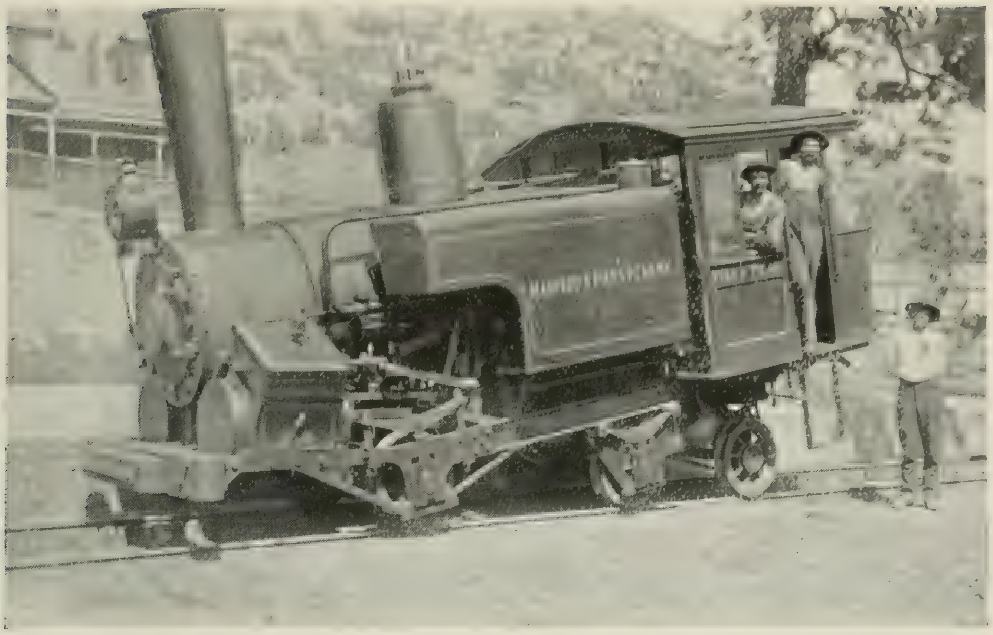
Sometimes the chains or cables would give way, and the resulting wreck of the cradle and canal-boat at the base of the incline would demonstrate the erratic flight in all directions possible to water when thus rudely disturbed.

The introduction of the steam railroad made a revolution in inland traffic, but natural obstacles were found to be a great limitation to their location. The railroads seeking new country, and



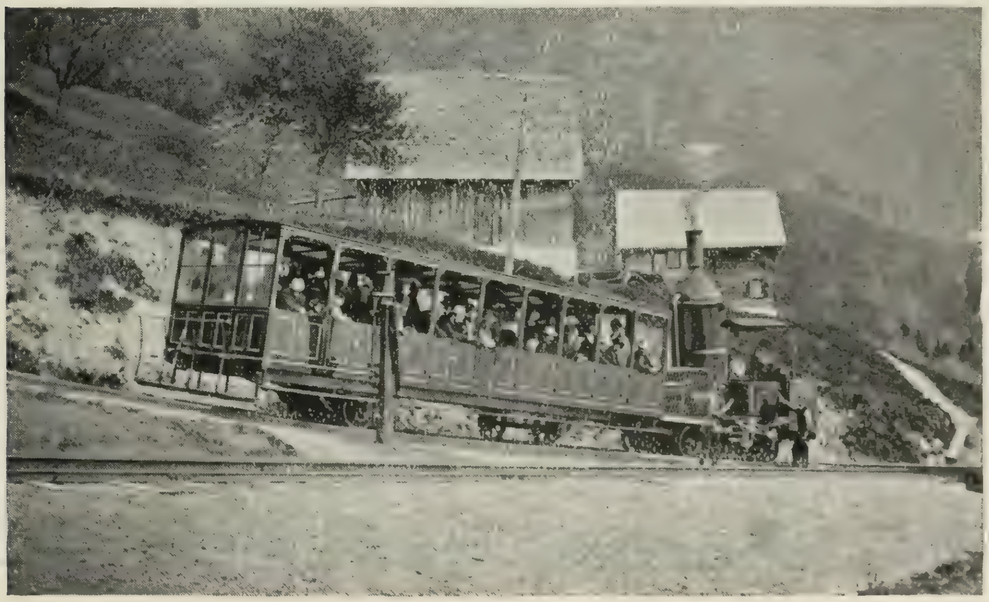
THE PIKE'S PEAK RAILROAD, ROCKY MOUNTAINS.

[Abt System Rack Road. Completed 1892. Maximum Grade, 25 per cent.]

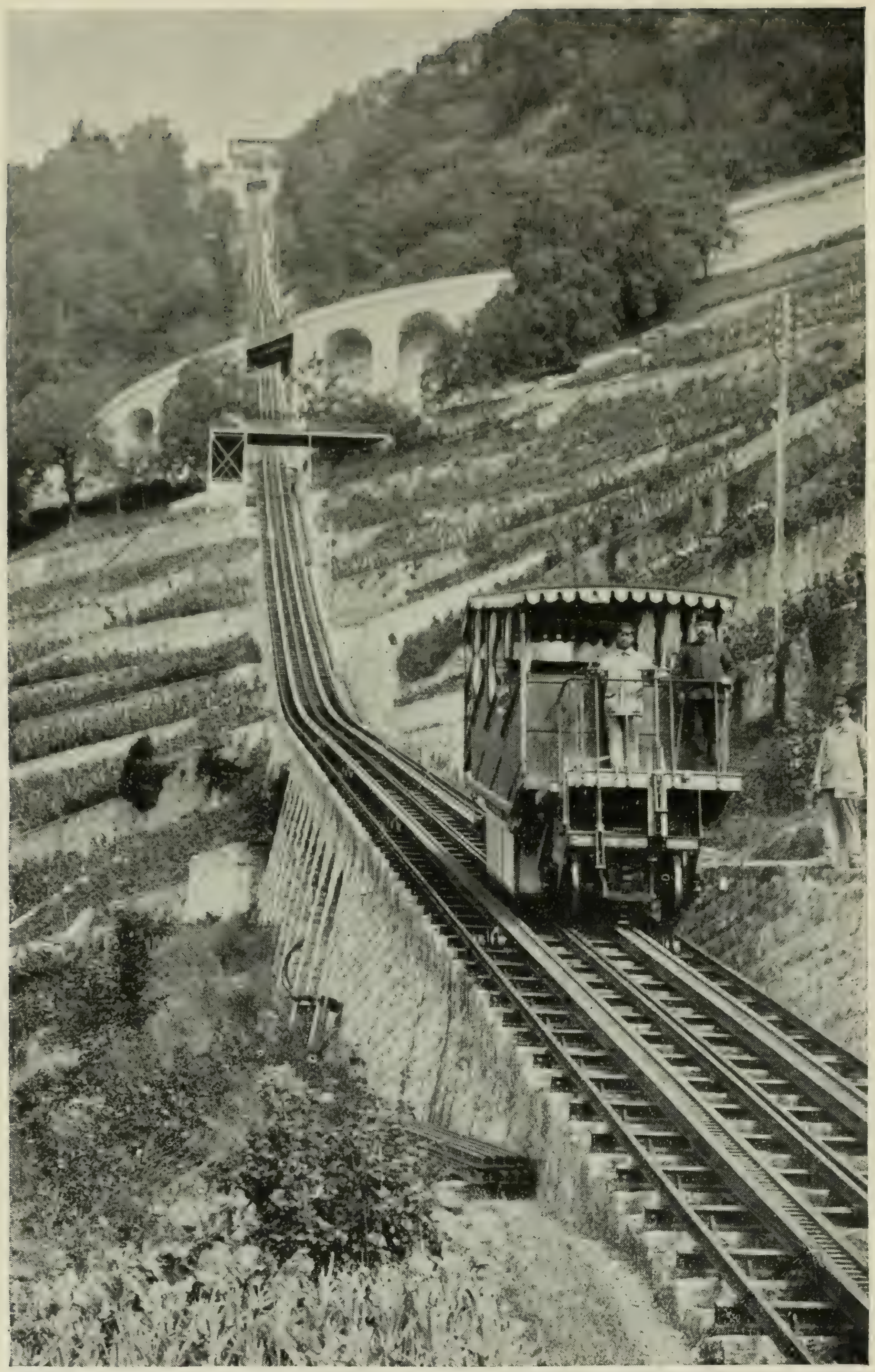


ENGINE USED ON THE PIKE'S PEAK ROAD.

therefore departing from the populous banks of the large rivers, met hills to be climbed and soon demonstrated the impracticability of ascending more than very gentle inclines. The key to successful railroad location has always been in conforming to the natural drainage of a country, or, if departing from it, in passing as soon as possible from one system of drainage to another. At present on the great trunk-lines it is considered that the rise of one foot in a hundred should be the maximum for regular grades, any greater rise requiring assistant power



TRAIN ASCENDING THE RIGI ROAD.

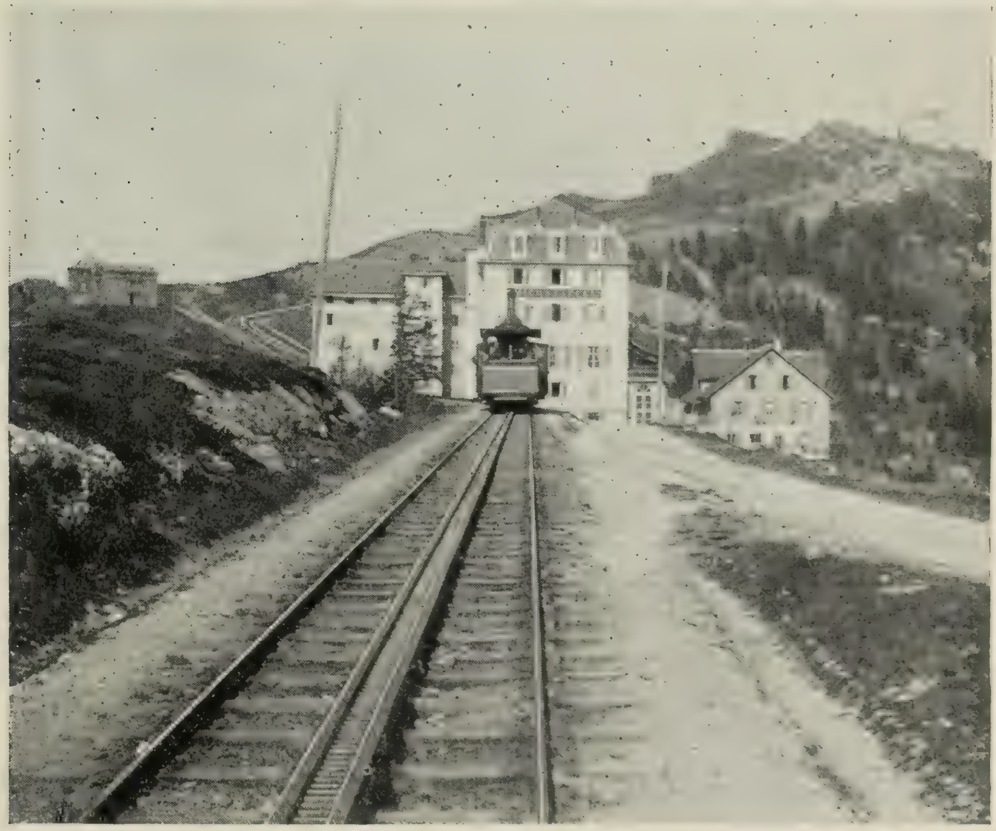


GLION CABLE WATER-BALANCE RAILWAY, SWITZERLAND.

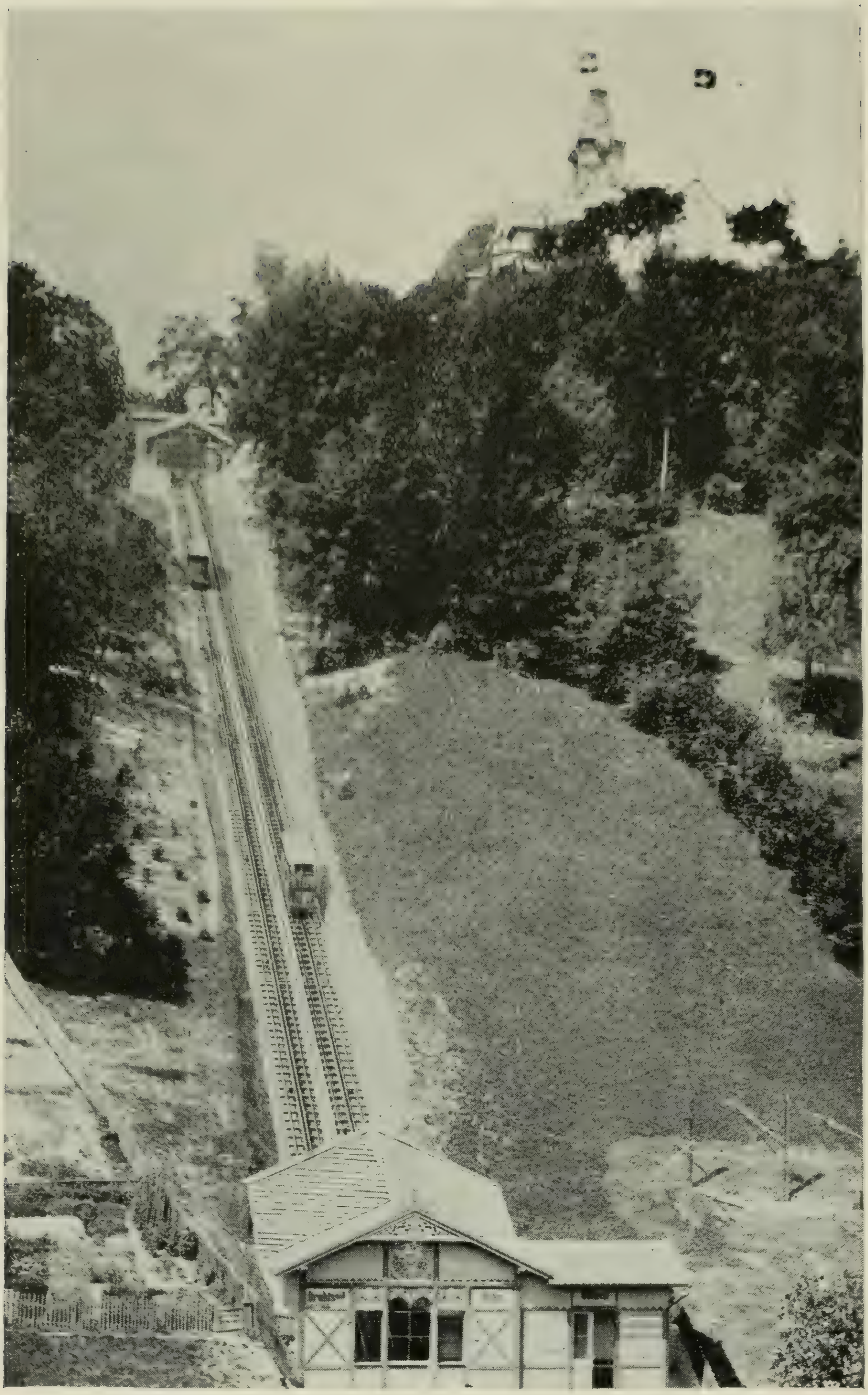
[From Montreux to Glion, on Lake Lemon. Rise 997 feet. Maximum Grade 57 feet in 100.]

to move the maximum loads. Like the weakest link in a chain, the steepest grade on a railroad limits the carrying capacity. Though many roads operate grades of three and even four feet to the hundred, these relatively steep climbs are most uneconomical, involving extra expenditure in all departments of the service. Short railroads, with the burden of traffic mostly in the downward direction, and narrow-gage railroads, with light rolling-stock, operate even heavier grades, but at a serious disadvantage.

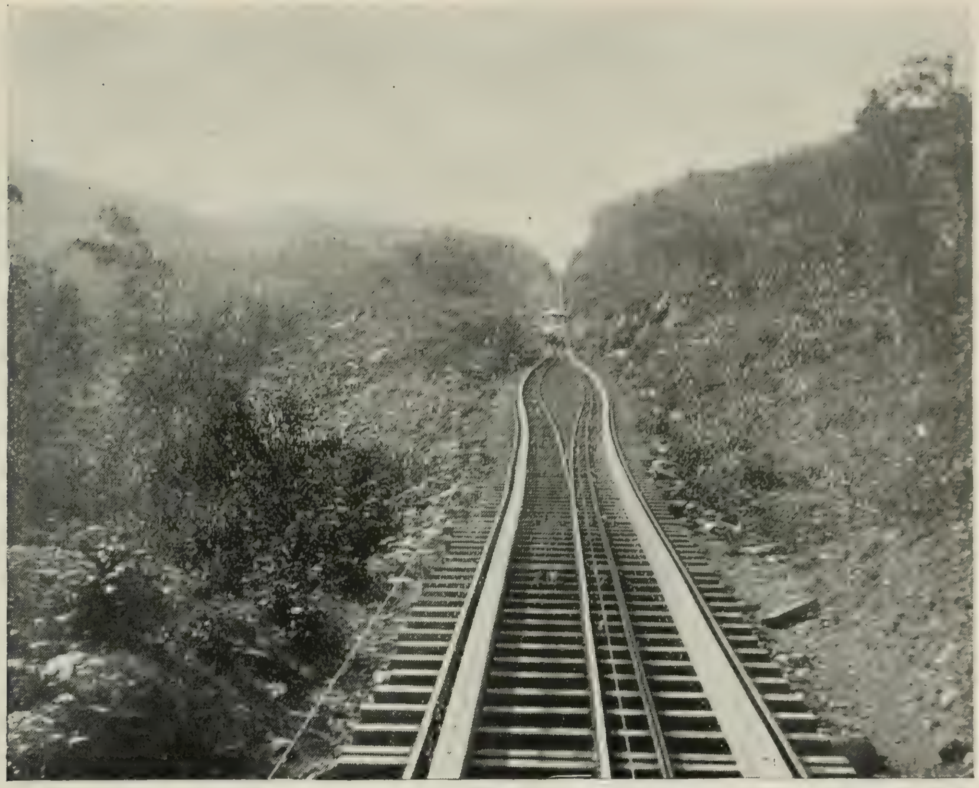
Therefore, to get over mountain-ranges, extraordinary developments have become necessary. Departing entirely from the direction of the objective point, a road is sometimes located in snake-like loops which turn along the hill-sides, up to the heads of ravines, the road coming almost back upon itself, all in order to make distance in which to "get up," without exceeding the maximum grade adopted as being practicable when considered in relation to the supposed future traffic. Remarkable examples of such development are to be seen in the numerous crossings of the Rocky mountains and the mountains of the Pacific slope, and a fine example is noticeable in the ascent of the Allegheny mountains by the Pennsylvania railroad from Altoona to



VIEW AT SUMMIT, RIGI ROAD, SHOWING LADDER RACK.



CABLE WATER-BALANCE INCLINE, AT LUCERNE, SWITZERLAND.



[Photograph Copyrighted by Loeffler, Tompkinsville, S. I.

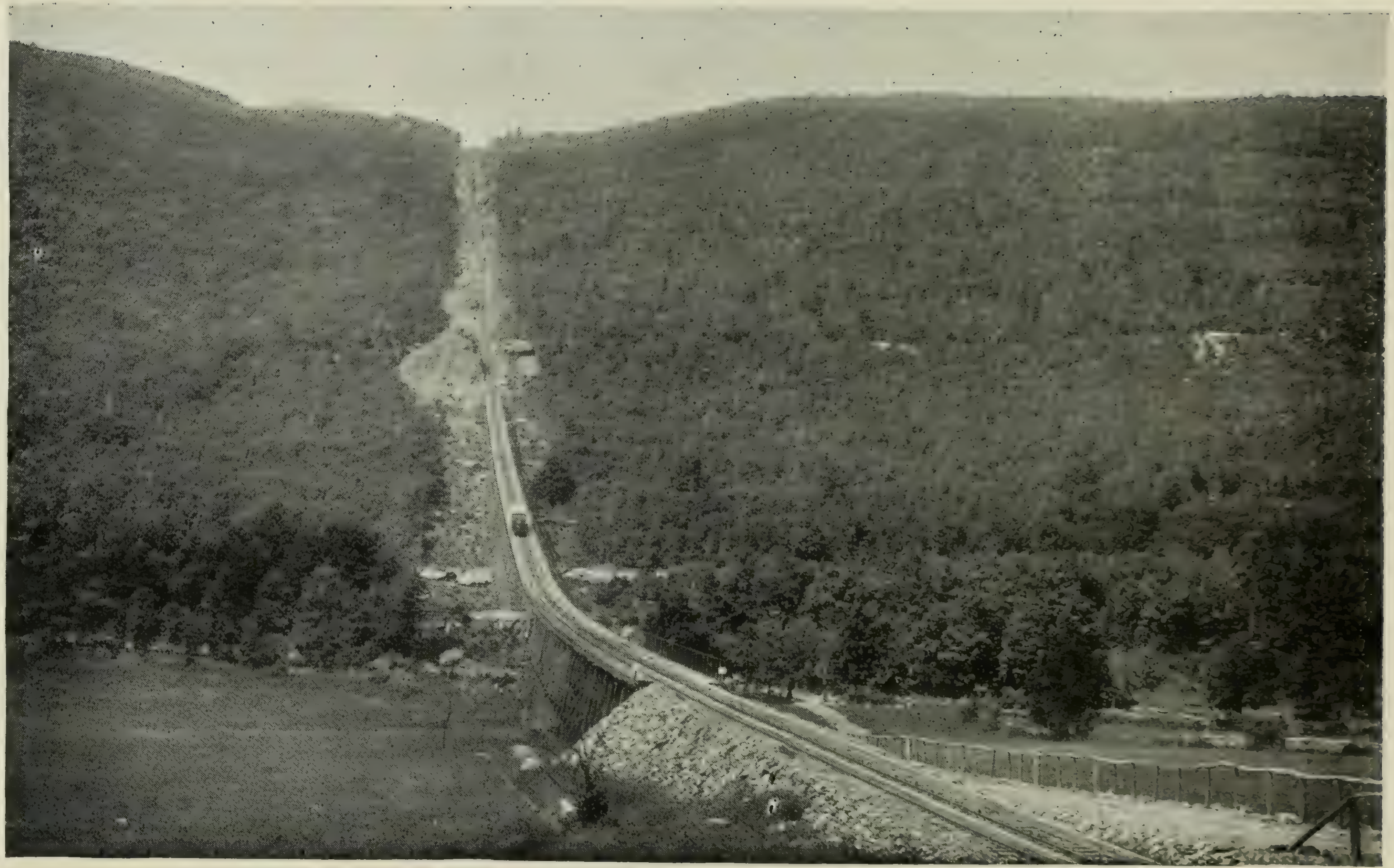
OTIS ELEVATING RAILWAY, CATSKILL MOUNTAINS.

[Showing Passing Point of Trains. Grade at this point 29 feet per 100.]

Cresson, around the famous "horse-shoe." The mountainous regions of Europe are threaded in a like interesting manner.

But the enormous expense entailed by the unproductive length of these roads and the time consumed in transit led eminent engineers many years ago to predict that, on account of the great advancement made in utilizing power, these great developments would be partially if not largely abandoned, and inclines with their increased directness and economy of time substituted. Prior to the adoption of these extended developments millions of money were expended in the endeavor to supplement the limited tractive power of locomotives by the use of cogged rails; also the supplying of auxiliary stationary power at points on the mountain railroad lines where steep grades seemed indispensable.

The old Portage road, crossing the Alleghenies and connecting the two canal systems east and west of those mountains, was a series of levels and inclined planes, steam winding-drums with ropes or chains supplying the power necessary to mount the heavy grades. This road was projected in 1829, and upon its subsequent completion became the overland connecting-link between the trade of the Mississippi val-



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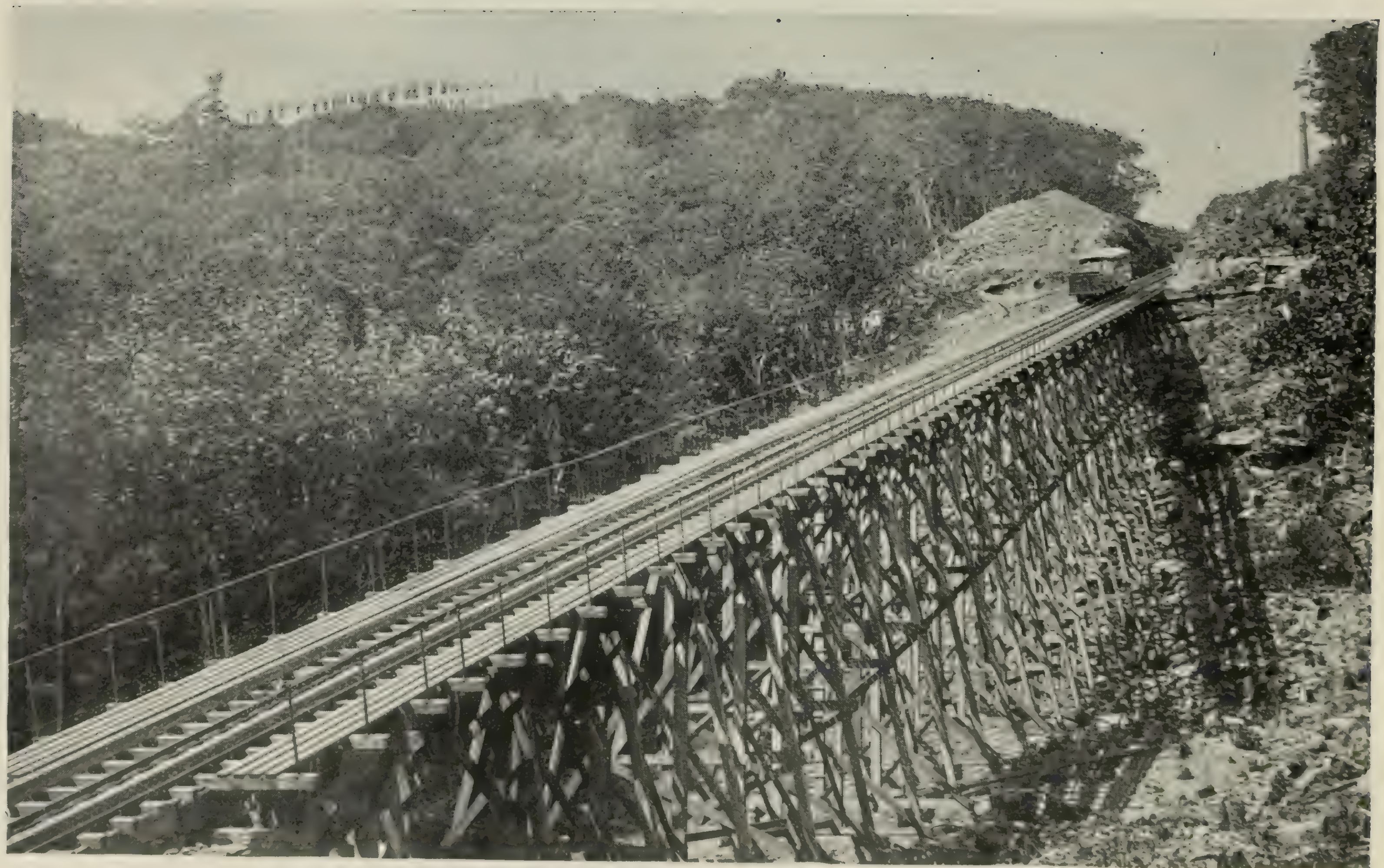
OTIS ELEVATING RAILWAY, CATSKILL MOUNTAINS, FROM LOWER TERMINUS.

[General View of Line Showing Compensating Curved Grade. Ris 1600 feet in 6780 Horizontal Length. Maximum Grade 35 feet per 100.]



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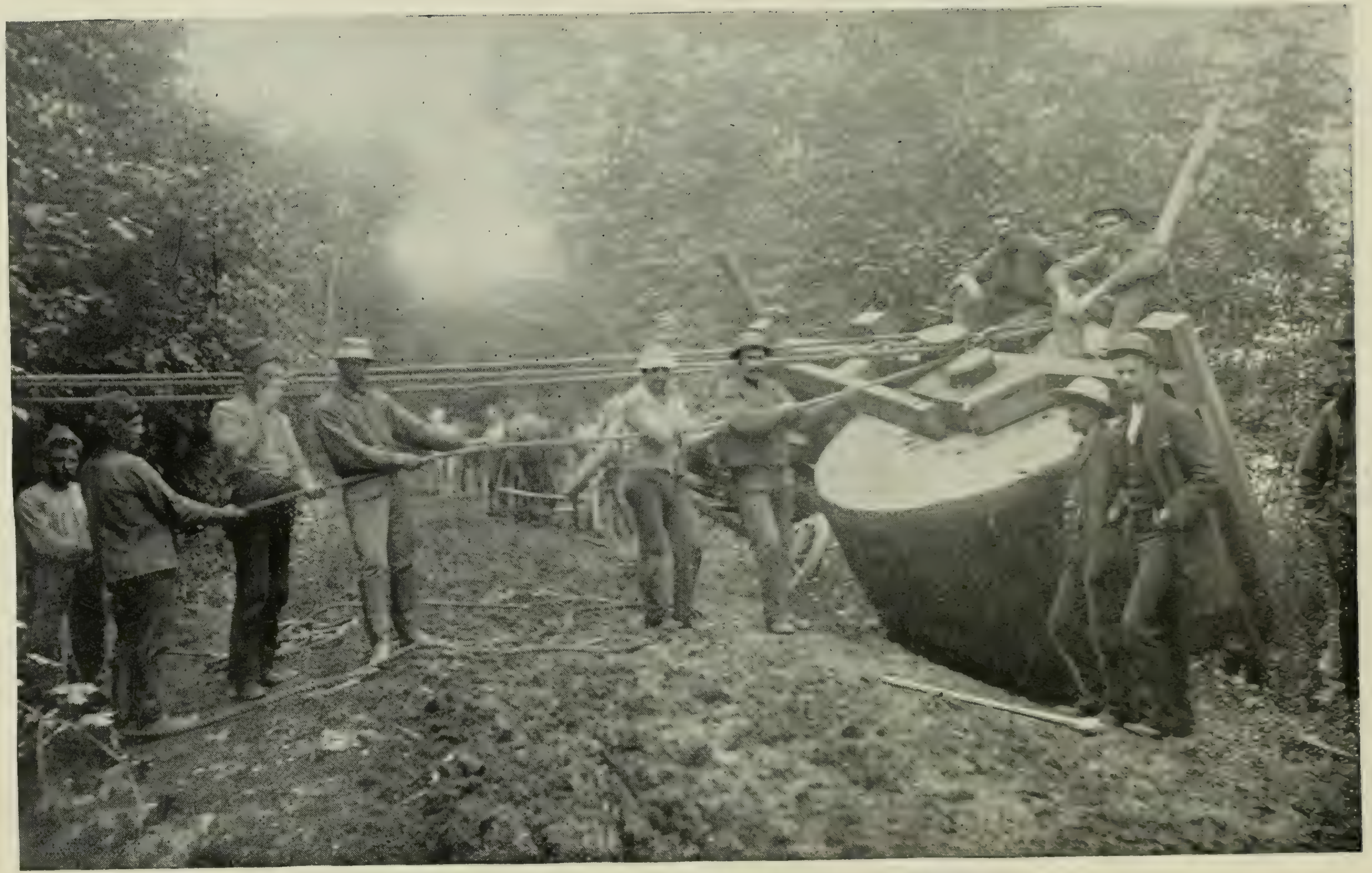
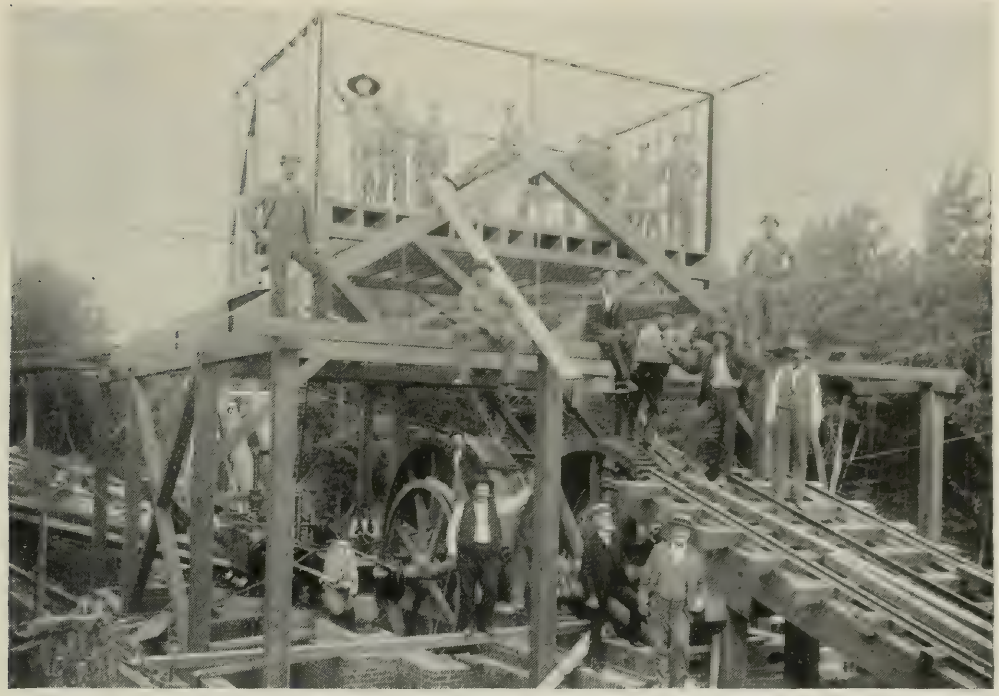
TRESTLE ON OTIS ELEVATING RAILWAY, CATSKILL MOUNTAINS, NEAR SUMMIT.

[Height 72 Feet. Old Mountain House in the Distance.]



A SPECIMEN DIFFICULTY IN MOUNTAIN RAILWAY CONSTRUCTION.

[Eighteen Thousand Pounds of Cable for the Otis Elevating Railway, Catskill Mountains, Ditched near a Precipice.]



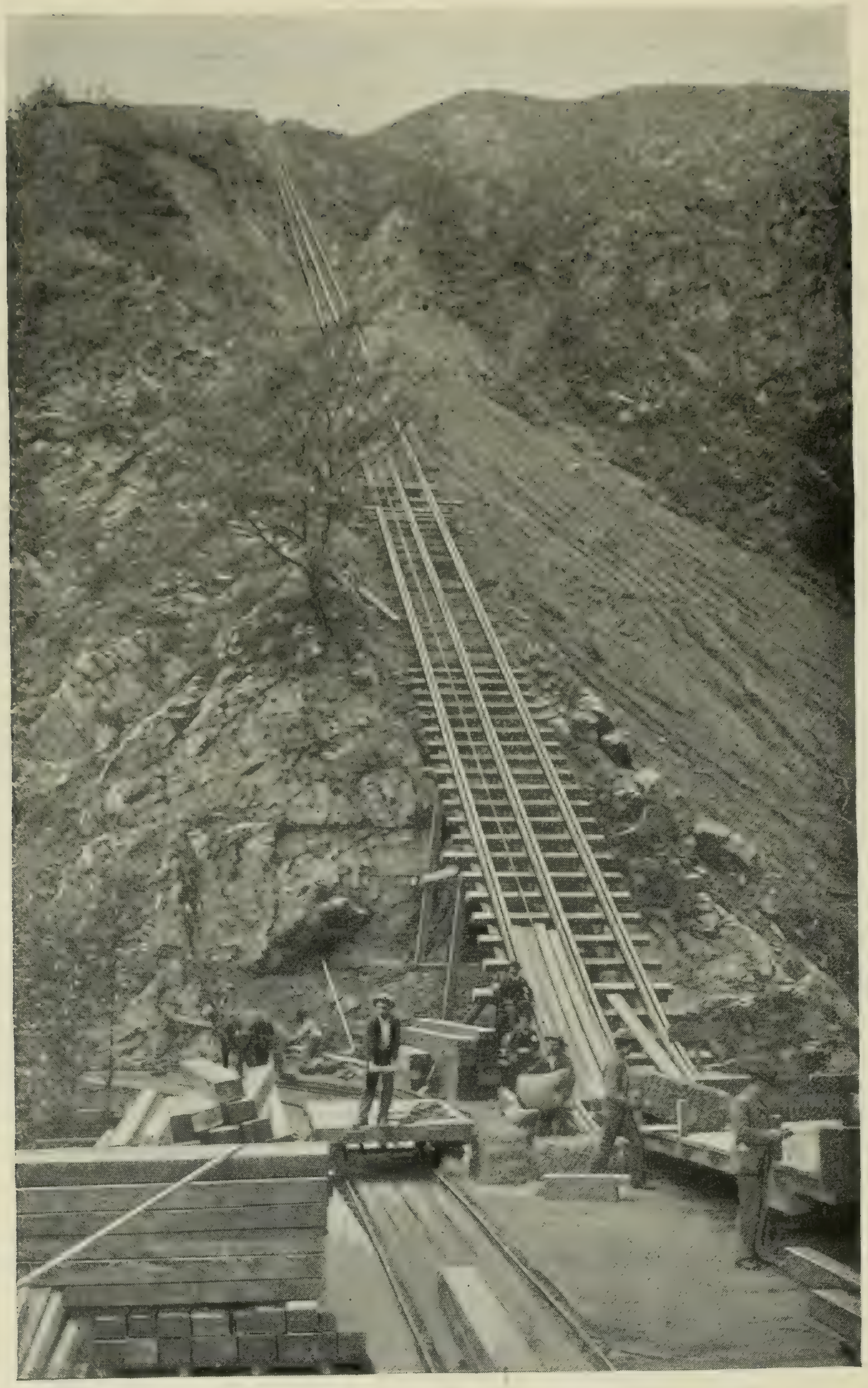
OTIS ELEVATING RAILWAY, CATSKILL MOUNTAINS.
[View of Power-House at Upper Terminus During Construction.]

ley and the Atlantic coast. This road was designed and located by the famous engineer Moncure Robinson, and was the great engineering feat of those days.

As long ago as 1812 a toothed rail was used in England on a road built and operated between Leeds and the Middleton coal-pits. This road was the invention of Blenkinsop, but improvements upon this system were of minor account until 1866, when Sylvester Marsh laid his locomotive ladder to the summit of Mount Washington, in New Hampshire. This ladder or center rail was made of two wrought-iron angles laid parallel midway between the main rails and connected by horizontal wrought-iron rounds.

Between these rounds the teeth of the pinion-wheel were inserted, and when the locomotive revolved the pinion the teeth caught each successive round of the ladder, thus producing the climbing action which overcame gravity on a maximum grade of 1 foot vertical to 2⅔ feet horizontal. This railway was completed in 1869, since which time, for a period of twenty-five years, it has safely conveyed thousands of tourists to the lofty summit of Mount Washington, without the loss of a single life.

European engineers were quick to learn of this great achievement and the rack system was much improved by them. The world-famed mountain region of Switzerland was soon to be invaded. In 1870



PASADENA ELECTRIC CABLE INCLINE, SIERRA MADRE RANGE, CALIFORNIA.

N. Riggenbach built the Vitznau-Rigi, which was followed some years later by the construction of the Arth-Rigi. Riggenbach did away with the round teeth and substituted trapezoidal teeth, with a system of involute gearing. Abt reduced the jar and disagreeable vibration due to the engaging of the pinion-teeth in the rack by using a double rack and double pinions, the teeth in one rack being approximately opposite the spaces in the other, thus obtaining a more constant pushing power. The Abt system, with its varying mechanical details, is generally acknowledged to be the most complete development of the rack road, and has been adopted throughout Europe.

Mt. Pilatis is a notable example, but in this case the locomotive has horizontal pinions which engage horizontal teeth projecting from both sides of the center rail. As the grade of the Mt. Pilatis road was necessarily about 48 feet to the hundred, it was feared that on account of this steepness the engagement of a vertical pinion with a rack having teeth perpendicular to the plane of the incline might be dangerous ; hence the change of detail as described. In the Rocky mountains the Pike's Peak road was built on the Abt system and is successfully operated with a grade of 25 feet to the hundred.

The scope of this article does not admit of describing the many roads in the Alpine mountains and elsewhere, notably in South America,* that combine the ordinary traction system and the rack. In these cases the rack is placed between the rails only where the traction grade is exceeded, and at such points the engineer slackens speed, the pinion comes into action and his engine becomes a mountain-climber until, arriving at the next comparative level, he speeds away.

It is a significant fact that all these roads are used for the transportation of pleasure-seekers only, and seem to have led to no material progress in solving the great traffic problem on a commercial scale. Speed is unattainable and there are many other conditions of limitation. We are therefore led back to the old idea of a combination of traction grades with cable inclines, which of late years have undergone a great advancement in efficiency and economy.

The simplest form of the cable incline is the water-balance, and, when nature favors and provides an ample water-supply at an elevation equal to that of the upper terminus of the road, no other system can be employed with like economy. An old-time well, with a rope passing over a pulley with a bucket attached to each end—one bucket coming up as the other bucket goes down—illustrates the principle, except that in the case of the incline the water is at the top, and in going down raises the lower bucket by its descent. To the ends of a cable passing around a sheave at the top of the incline two cars are attached, provided with water-tanks capable of being rapidly filled or discharged. The difference in the weight of the ascending and descending loads, together with friction, is all that has to be overcome. The upper car is made the heavier by filling its tanks with water; in its descent it raises the lower car and upon arriving at the bottom discharges its load of water preparatory to receiving its load of passengers and freight. The water required is only the amount necessary to augment the weight of the descending load so that it will overbalance the ascending load, the rapidity of motion being controlled by friction-brakes, either at the top of the machine or on the car.

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* There is an important example of the combination system, constructed recently, at Rio de Janeiro, and another exists at Buenos Ayres.

When the upper live load is in excess no water is necessary, and only the regulation of the speed of the natural descent is required. To regulate this speed a rack is laid between the main rails similar to the rack of the steam roads, and a pinion-wheel in the car revolves upon it. A friction-brake on the pinion gives absolute control, which would even allow the car and load to make a safe descent with the cables detached.

The Glion railway from Montreux, in Switzerland, is a water-balance incline operated exactly upon the principle described. The rise is 997 feet, with the remarkably steep grade of 57 feet vertical to 100 feet horizontal, and the trip from the foot to the summit of the incline is made in seven minutes. The construction of the Glion railway is most thorough; the track is supported when not incut by arches of solid masonry, and about midway up it crosses, with a stone viaduct, the highway skirting the mountain-side. There are many smaller water-balance inclines in Switzerland. At Niagara, in America, a short one runs down the cliffs below the falls, on the Canadian side, to the whirlpool rapids.

In the Catskill mountains there is a striking natural opportunity to employ the same method. North and south mountains rise side by side on the eastern edge of the picturesque range, and nestling between these peaks is a pocket the elevation of which is about 2200 feet above the Hudson river or 1600 feet above the immediate main valley, while the summits of the two mountains rise on each side some 800 or 900 feet higher. The drainage naturally flows into the pocket and forms two pretty mountain lakes that discharge into the deep Kaaterskill gorge, running back and away from the eastern slope at this point. A simple ditch about 300 feet long, and with no greater depth than fifteen or twenty feet at the highest point, would divert the waters of these lakes and empty them directly over the face of the mountain into the valley of the Hudson; therefore the lakes form an ideal supply both in quantity and proximity for the operation of a water-balance incline of immense proportions. In 1886 surveys were made and a line located by the writer of this paper with this end in view, but, though nature had furnished the water, the laws of the land gave proprietary rights to adjacent land-owners, who objected to its use, and thus the project was for a time abandoned. The incline finally completed at this point, two years ago, is now run by steam.

The great economy of the water-balance is apparent, but when the natural conditions do not favor it some other power than simple gravity must be employed; hence the use of grip-wheels or drums at the head of the incline driven by steam or electricity to move the cable upon the ends of which the cars are attached the same as in the case of the water-balance. This is also an economical method, as the descending load always lends the power of its gravity to aid in raising the ascending one. Inclines of this description are very numerous; generally three rails are laid, the center rail being used in common by both cars, and a turnout provided at the middle of the run to enable the cars to pass.

At Mount Vesuvius two inclines are operated, one a continuation of the other, their combined length along the run of varying grades being 10,500 feet. Mount Supurga, Italy, comes next with a length of 10,243 feet, with a rise of only 20 feet to the hundred. The road at Mount San Salvatore, Italy, rises 1973 feet in a run of 5358 feet, but is really two inclines each with one-half of this rise. At Burgenstock, Switzerland, the rise is 1444 feet, with a grade of 57 feet vertical to 100 feet horizontal. These are the great cable inclines of Europe, and there are many lesser ones. In most of these cases a rack is used with a pinion controlled by a friction-brake to guard against accident in case of the cables parting. In America there are also many small cable inclines: several in Pittsburgh and Cincinnati; one at Lookout mountain, with a rise of 1170 feet to a run of 4360 feet; and at Pasadena, California, there is an incline in connection with a general system of electric railways, where electricity is used to revolve the grip-wheels or drums. But the steam cable incline finally constructed at the Catskill mountains is the greatest in America, having a total rise of 1600 feet in a horizontal distance of 6780 feet.

There are some peculiar features in the construction of the Catskills incline which are worthy of comment, as they mark a decided advancement in this line of engineering work. This road was built in 1892 after the designs and under the direction of Mr. Thomas E. Brown, Jr. The first radical departure from old-time methods was in the adoption of a grade on a vertical curve so graduated as to result in compensation for the shifting of the great weight of the cables from one side of the road to the other, which, of course, would occur at every trip. When starting the resistance to be overcome is not only the weight of the lower load, but also the entire weight of the cables,—and these wire ropes weigh 35,000 pounds. But as the lower load ascends this weight is constantly decreasing, for the cables, passing around the friction-drums, follow the descending load and add their weight to its gravity power. Consequently, in order that the engine shall only be called upon to exert a uniform power at all stages of the trip, and to perform the most economical work, the grade is made lightest at the bottom, but constantly increases with an upward curve in exact proportion as the weight of the cable is transferred from an upward resistance to a downward pull. It will thus be seen that the grade becomes steepest at the top, and by this compensation the shifting of the great weight of the cable is eliminated from the problem, the descending load always exerting the greatest gravity power at the time when there is the most to lift and its assistance most needed.

The Catskills incline also does away with the expensive rack and the pinion-wheel on the car for purposes of safety, and substitutes a clutch which is automatic in its action. A wooden stringer acting as a guard-rail is laid on the inside of each outer rail, this road having three rails with a center turnout as before described, and upon the top of this guard travels a friction-wheel attached to the car. Inside of this wheel are toothed weights that act like the governor-balls on a stationary steam-engine. If, due to any cause, as breakage of the cables or derangement of the machinery at the top of the incline, the car exceeds a safe velocity, the governor-weights fly out, and, throwing in the clutch on the wooden guard-rail, the car is brought to a stop.

Many other new devices have been employed in the construction of this road tending to the safety and convenience of traffic. But, more than this, the Catskills incline has demonstrated an economy far greater than previously attained by any of the steam cable inclines of the world.

There are many circumstances that arise during the construction of inclines which make such work somewhat different from ordinary railroad construction ; materials of all kind develop a wonderful facility of getting away, and every man is more or less in jeopardy from possible carelessness on the part of any of his fellow-workmen above him. In ordinary work, if a rail slips the tongues it remains to be picked up again. Not so on the incline where mishandled material starts on a wild course of destruction toward the foot of the mountain. Careful provision must be made for anchoring the whole roadbed to prevent a general slide.

The substantial method in Europe of using solid masonry to this end is of course the best. But it has been proved, by the many successful structures of wood and iron in the United States, that such a large first cost is not imperative.

In conclusion, is not the engineer justified, by such advancement and improvement in economy, in speculating upon the future of the incline and the possibility of its substitution in many cases for the long and uneconomical railroad developments in mountainous country now so universally adopted? It must be admitted that where traffic is very intermittent the day has not yet arrived when the incline could be economically applied, but where traffic is almost continuous in both directions, as in the case of the Pennsylvania railroad at Altoona, why should not the wasted gravity force developed in trains passing from the summit to the valley be utilized in the assistance of trains climbing from the valley to the summit? Trains could run upon inclines as they now run upon transportation barges, and, after the few minutes consumed in ascent or descent, shoot away on the levels at their mile-a-minute speed, thus saving hours of time and seemingly endless miles of circuitous construction.

GOLD AND SILVER IN SOUTH AMERICA.

By Arthur L. Pearse, M. Am. Inst. M. E., M. I. M. E.

THE modern world has not been as much interested at any other time as it is now in the quantity of precious metals produced and in the outlook for future production. Formerly the question was one that interested chiefly adventurers, mine-owners, and speculators, the great mass of people not being concerned about a matter that did not appear to touch them nearly. But now the monetary discussions in all the great nations of the world and the radical changes of legislation have taught everybody that no question comes closer to individuals than the monetary question ; that no influence is more potent for the making or undoing of private prosperity ; and that no power is stronger for the welfare or the injury of the state.

The specific question now is : whether the fall in the price of silver is going to diminish materially the production of the white metal, and whether the appreciation of gold will increase the output of the yellow metal. It is to contribute some material towards an intelligent answer to these two highly-important questions that I have, at the request of the editor of the Magazine, prepared this paper. I have spent many years in South America, having left only within the past few months, so that my experience will probably be held as a sufficient justification for writing. It is intended to take up the various countries *seriatim*, to point out as comprehensively as space will permit the existing conditions, and to forecast as carefully as may be the future.

CHILE.

Let us begin on the west, following the coast around in the geographical order of the countries. Chile at present contributes to the metallic stocks of the world about equal values of gold and silver ; the gold output being about $1,500,000 and the silver-production averaging about 3,000,000 ounces. Its output of the more valuable metal has been fairly constant for 350 years, as we know from scrupulously-kept ancient Spanish records. It reached a maximum gold-production of $2,000,000 in 1888, through the profitable workings in that year of the Guanaco gold-fields. This deposit is still worked extensively, but the results of late years have been disappointing.

The alluvial and placer deposits of the country have all been worked out by the Indians ; all mining is now in quartz. The principal gold-centers are in the departments of Rancagya, Aconcagua, Coquimbo, and Atacama. In the latter department is Taltal, where a number of mines are worked on a small scale, and where a large number of "beneficiating" (reduction) establishments have been started. These buy the ores in small quantities from small miners, thus permitting production to proceed with limited capital and plant. Until lately Chilean ores have been held hard to work and difficult of amalgamation. The high percentage of loss in reducing was attributable, however, more to the fineness of the particles in the gangue than to any initial refractoriness in the ore. Of late improvements in methods have had a most satisfactory result in largely increasing the percentage of metal saved, notably at the Atacama works at Taltal, where works are also in course of erection for the beneficiating of ores by means of the cyanide process.

A considerable amount of the Chilean ore is of extremely high grade, and the custom still obtains of shipping such ores to Europe for reduction. The results justify the enormous freight-charges when the ore runs from 10 to 15 ounces of gold, which is often the case. I once saw a picked three-ton lot of Guanaco ore running 600 ounces of gold to the ton. In the southern parts several small concerns are working and extracting gold, and there are most promising prospects in the Copiapo district. The mines there have all the elements of success, but the natives lack the energy to develop their resources as rapidly as would be done in the United States.

Chile reached its maximum of silver-production in 1886, when the output was 8,725,000 ounces. The increase was accounted for by the discoveries at the Caracoles mines, which have since failed. The Chilean silver-ores are notably easy of working, as the metal is found either native, as a chlorid, or an iodide. Silver can therefore be produced cheaper in Chile than in the more northern countries—Peru, for instance—where the ore is more refractory. The oldest silver-mines in the country, which are still producing, are near Iquique, at Huantajaya, and in the district of Cachinal. They present the curious condition that the metal is found in the lode in great pockets, so that, from time to time, large quantities of rich ore are found.

A prejudice exists against Chilean mining. People think, because some lodes near the coast have turned out to be gash veins, and because some of the promising mines, such as the Guanaco, have proved to be "blow outs," with only superficial and early exhausted deposits, that there is no prospect for deep-mining. They forget that copper lodes have been followed down at several mines in Chile for 500 meters, and that there is geological reason for supposing that the true gold lode should be equally constant in depth. It seems obvious that the mineral resources of the country are by no means beginning to be exhausted, and that Chile has before it many generations during which it will contribute to the mineral wealth of the world. Vast districts, especially near the desert of Atacama, are still open to the prospector, and lodes of silver, copper, and gold are constantly being discovered. There is no doubt that a great number of good mines yet remain to be found. It is not many years since some of the most successful mines were located, the Caracoles, the Arturo Pratt and several of the best mines in the Guanaco district ; many people are still constantly engaged in looking for gold and silver, and in developing new interests.

The influx of capital is encouraged by laws highly favorable to the mining interest, founded on the old Spanish code. The taxes amount to only ten pesos ($3 in gold) per annum for each *pertenencia* (claim), and, if they are not paid when due, there is a concession of considerable time during which the delinquent does not lose title. There are also provisions against the seizure of mines for debt. Yet capital is timid about investment in Chile. The crash that followed the over-development of the Argentine and the revolutions that have, like the measles, run their course from one South American state to another have prejudiced the moneyed interests of the United States and of Europe against all investments in the southern continent ; and it is likely to be some years before mining capital will flow freely into Chile. Those who have had the pluck to go in there with money have been handsomely repaid. War and revolution have not materially affected their interests. The labor of the country is the best in South America. The native Chilano is hardy, intelligent, and an intuitive miner. His wages are paid in paper pesos now worth say 30 cents, or 15 pence. Three of these paper pesos is an average day's wages.

It will be gathered from the foregoing that the diverging values of the precious metals will not have much effect upon the mineral industries of Chile. The fact that the currency of the country is a debased paper currency stimulates production and helps the export of silver. Some mines that have been struggling on for some time just paying, or not paying, will probably shut down ; while others will increase their output capital and energy will naturally turn to the development of gold rather than of silver interests.

BOLIVIA.

Bolivia has been benefited in reputation by being in the interior and difficult of access ; distance has lent enchantment to the view. The most exaggerated stories are in circulation relative to its mineral wealth, and thousands of practical miners believe that vast riches are hidden in the interior. In my own judgment, the country as a whole is vastly overrated, the major part of its production coming from a few centers. It has in fact almost ceased to be a gold-producing country, its output in 1891 having amounted only to $67,000. Its gold produced is, however, subject to such variations as are all placer-mining countries, and rich discoveries in limited areas sent its out-turn in 1871 up to the maximum in three centuries, namely, $1,500,000.

There are few white people engaged in mining, owing to the small temptations of the limited return and the hardships and isolation necessary to be endured. There are a few adventurous prospectors traversing the country, but the results of their arduous endeavors have not been such as to encourage others to follow their example. Lately, however, an organized investigation of certain parts has been going on with more of system than has before been attained. It seems that a New York syndicate are exploring the Beni-river country primarily for india-rubber, and that they are also prospecting for gold.

The small amount of gold now produced is panned out by the native Indians, with the crudest sort of appliances; but the placers are practically exhausted. Such examination as I have been able to give to the placers and gold-ores of the country convinces me that they are largely of low grade, and of nothing like the average value generally represented. Bolivia is, however, a large producer of silver, its out-turn running about $15,500,000 annually, half of which comes from one mine. It is an interesting evidence of the strength of its silver resources to recall that the product of the country in 1550 was $7,500,000. The considerable yearly output comes from a few large mines which yield generously, and it is certain that the output of these mines must be stimulated by the low price of silver. The metal is like the product of a textile factory—if the goods fall the manufacturer must sell more. At the Huanchaca mine, the output of which last year was $8,500,000, they have spent over $1,000,000 in a reduction-plant at Antofagasta, the seaport, the object being to reduce the ores heretofore of too low grade to pay for working on a smaller scale. The railway from Antofagasta to Oruro was completed a few months ago, and a new country will be opened up of several hundred square miles. But there is no apparent likelihood of any considerable increase in the gold-production.

Some of the smaller silver-mines that have been shut down would undoubtedly be running if silver were ten or fifteen cents higher in price; but against this must be reckoned the increased output of the larger concerns. The principal silver-producing centers of production are Huanchaca, Cerro de Potosi, Colquechaca, Oruro, and Aullagas. There is also a large and possibly productive tract containing gold placers in the eastern and northern parts of the country, of which comparatively little is known. The probabilities are that this tract, which adjoins and is geologically identical with the Peruvian provinces of Sandia and Carabaya, is neither better nor worse than these districts, which I will mention in connection with Peru.

PERU.

The ancient records show a large output of the precious metals from Peru, but it is probable that a great part, if not the chief part, came from what are now known as Ecuador, Bolivia, and north Chile. The present gold-production is only about $75,000 per annum, of which $50,000 comes from one mine in the Sandia district. This and Carabay are auriferous districts of vast extent over the Andes, adjoining Bolivia and among the head-waters of the Amazon, but they have been uniformly overrated. No doubt some of the placers are fairly good, but the best of them are at so high an altitude that no adequate supply of water can be brought to bear, and in consequence production is limited. The Sandia deposit is probably the largest bank of auriferous gravel in the world. It is the only bank in Peru ever equipped with modern hydraulic appliances. Its present return of $50,000 per year might easily be quadrupled. Other gold-fields are those of Pallasca and Pataz. The difficulties of distance and height must always prevent the adequate development of many otherwise promising lodes and placer deposits. Although there is still a field in Peru for the prospector, I believe that only one organized prospecting party is now traversing the country. Nearly all of the gold produced outside of Sandia is washed out by Indians with wooden pans.

A number of well-formed lodes have been discovered in the Pallasca district, and only await the coming of capital for adequate and, I think, remunerative development. This district is in the second range of the cordilleras, 7000 feet above sea-level, in a region of perpetual spring, but it is 100 miles from the nearest railroad. The specimens that have come to hand from a lately-discovered district behind the port of Chala, and the reports of a few competent judges who have been over the ground, indicate that exploration might prove this to be a gold country of exceptional richness. All through the country are small locations which might be worked at a profit elsewhere than in Peru, but the natives will not take the trouble to develop them.

Peru ranks next to Bolivia in the production of silver. In 1533 its yield was $1,250,000; in 1800 it was $6,250,000; and the present rate is a trifle over $3,000,000 per year. Its most famous mine and its largest total producer is the "Cerro de Pasco," which contains large bodies of oxidized silver-ores, easily accessible, but of low grade. It has been worked a century, but unless a large amount of capital is expended on it for deep drainage it has probably seen its best days. The silver-production is fairly well divided between four or five centers. The largest present producer is the Callyoma mine, the output of which finds its way abroad over the Southern railroad to Mollendo, which is also the outlet for much of the Bolivian ore. The bulk of the silver-ore is refractory, and the country is inadequately supplied with reduction-works. The practice is to ship selected high-grade ores to Europe for reduction.

There are large bodies of low-grade silver-ores in many parts of the country, notably in the Callyoma district and at Carahuacra. Some day these bodies will no doubt be adequately and systematically worked, but the present low value of silver will have a great influence in retarding development. The height above sea-level at which most of these bodies lie is phenomenal, and this no doubt constitutes a serious obstacle, particularly in the high cost of preliminary equipment. Such equipment in Peru will cost fully 100 per cent. more than in most countries. For years it has been supposed that smelting operations could not be carried on at all at great heights; but it has now been practically demonstrated that no real difficulties exist. The largest smelting-works of their kind in the country are those in successful operation at Casa Palca, 13,600 feet above sea-level.

Native labor is inexpensive, but requires constant and costly supervision. There is no gold or paper currency, and the monetary standard is the silver Peruvian dollar, or sol, weighing 25 grams of 900 fine. The mint at Lima is one of the finest in the world, and its coins are accepted as standard elsewhere in South America and in Europe. The basis of the mining-laws is the old Spanish code. Mines are subject to a small semi-annual tax of 10 sols (say $5 in gold). The laws are fairly administered, as a rule, but if the tax is not paid the day it is due the mine is subject to denouncement.

COLOMBIA.

Colombia, the El Dorado of the old Spaniards, has produced more gold than any other country of the southern continent, the total yield from its alluvial deposits being estimated to have reached $500,000,000. Its annual production, for many years, has varied little from about $1,250,000. It has not been a producer of silver until within late years, but some silver-mines are now being worked, of which the best known are those at Tolima. The total annual output of the white metal will not, however, reach $1,000,000 in value. The principal mining centers are in Antioquia and Cauca (including Choco), and in Panama and Tolima. The two first named are from 4000 to 5000 feet above sea-level, and have an excellent climate.

Antioquia is peopled chiefly by the descendants of Jews who fled from Spain in the time of Ferdinand and Isabella. They are thrifty and industrious and maintain a gold currency, whereas the other states of Colombia are on a silver basis. The province of Panama contains much gold; there is probably no river within its borders from which gold could not be panned. The riches of the Darien are historical and the mines of Cana, according to the authentic records of Panama, have produced some $80,000,000 in gold. The most promising part of this department is in the country of the Chucanaque Indians, between the Darien and Atrato rivers. This district has not been much explored, as its riches are protected by a dense tropical growth and by several thousand war-like and unconquered Indians. Large amounts of gold and india-rubber are traded by these Indians out through the San Blas country, and there is reason to believe, from the amount and nature of the gold, that there are rich alluvial deposits as well as powerful lodes. That this country will be opened up in this generation is improbable, but it is certain some time to contribute a material addition to the world's stock of gold.

There are good placers still untouched in the Cauca district, and between Cauca and the Pacific. The country is so densely covered with tropical vegetation, however, that prospecting is almost impossible. In other departments of the interior there is an admirable field for mining without the difficulty attendant upon operations in the more tropical parts. The output of the country can hardly fail to increase in the near future, as gold is universal, and modern methods of extraction are gradually being introduced. Access to the interior takes time, but it is not difficult. The main artery, the Magdalena river, is navigated by sternwheel flat-bottom boats for five days, to the head of navigation, whence supplies and machinery must be conveyed by small local railways, by vehicles, or by pack-animals, according to their destination. On the whole goods can be conveyed more cheaply than in many parts of Chile or Peru. The mining-laws are equitable.

ECUADOR.

The present gold-production of Ecuador is merely nominal, but preparations have been made to develop the placers known as Playa del Oro, on the borders of Colombia. An American company with large capital has gone in there with an extensive plant, and if only a small percentage of their highly-sanguine expectations is realized the result must be a material addition to the resources of the country. There is a great field for prospectors here, and doubtless a great deal of mineral wealth, but the difficulty of coping with the tropical vegetation and with the Indians,—one of the tribes, the Jibarra, being cannibals,—renders the development very slow. It is reported that good gold lodes exist in the interior, but nothing of importance has been done with them. One English company—the "Zuruma"—has been operating for some time, making gold shipments of $120,000 a year. Ecuador yields no silver, although its currency is of that metal.

VENEZUELA.

This country has produced a large quantity of gold within thirty years past, but the present decade has witnessed so serious a falling-off as to create fears that its richer deposits are becoming exhausted. Its output of metal has been nearly all taken from the district of Caratal, of which Cuidad Bolivar is the principal town. The district is reached from Trinidad by steamer up the Orinoco, and afterwards by a three-days' journey on mules. The cost of transportation is very great and only the richness of these mines would have justified the expenditure. Here is situated the famous El Callao mine, the greatest producer in its time that the world has seen. In close company are the Callao Bis, the Chile, La Union, etc., and many smaller mines and great numbers of prospects. The gold-production has fallen from $4,000,000 to $6,000,000, in 1886, to a little more than $1,000,000. Notwithstanding this considerable and progressive fall of output, it does not seem to me that the retrogression is likely to continue, and I look for an improvement.

The present prospects of the El Callao Company are better than they have been for years, and of late a considerable advantage has occurred in the cheapening of labor. There are other mines in the vicinity, especially the Chile, which should materially increase their output in the near future, with better processes and better management. All through the mountains of the country gold is to be found, but not yet in such quantities as to encourage the investment of foreign capital. The Caratal district has been fairly well prospected, but the rest of the spur of the Andes running east and west through the country offers a highly favorable field to the gold-prospector.

There is little silver-mining. The deposit of argentiferous galena near Carupano has been of some importance in the past, but the fall in value of lead and silver has resulted in the practical closing of the mines. The currency of the country is gold. The mining-laws are generally the same as elsewhere in South America, except that prospectors may secure title to larger areas than in the other states.

THE GUIANAS.

British Guiana, of which Georgetown is the capital, is the only colony that Great Britain has in South America. Low, alluvial plains extend some forty to seventy miles back from the coast. Beyond rises an eastern spur of the Andes, containing metalliferous rock. This mineral district is no doubt a continuation of that rich region of Venezuela that contains the famous mines of the Ciudad Bolivar district. Here lies the disputed land claimed by both countries, which produces from 8000 to 10,000 ounces of gold per annum, which is shipped through Georgetown, going to swell the nominal output of Guiana. The mineral wealth of British Guiana has been little developed, owing to the distance of the mines from any base ; to the difficulty of transportation; to the malarial climate; and to the slight attention that the colony, comparatively speaking, has attracted to itself as a gold-producer. At present there exists only placer-mining, whereas there is reason to believe that the real metallic wealth of the country lies in the mother lodes from which the gravel has been denuded. Prospectors have gone carefully through the country for years, and only last year some highly-valuable locations were made far in the interior, which promise to increase materially the output of the colony. The only method of working at present in use is hand-sluicing, the flatness of the country not lending itself to the hydraulic methods of California, where large quantities and high heads of water can be brought to bear upon the banks. Hence, in order to pay, the gravel must be of a high grade.

The people of Georgetown, who watch with a keen interest the development of their gold resources and who contribute to the development by investment of their money, are talking about a railway from the head of navigation on the Essequibo river to the principal center of the gold-washings, but its early construction is not probable. Meanwhile all communication is by boats propelled by the native Indians, who are peaceable but indolent. The negroes are the laborers and miners. Contracts are made with them in Georgetown, whence they are transported to the mines by boats, together with their provisions. There is considerable illicit traffic in gold at Georgetown, with the blacks, and as much money has perhaps been made by individuals in this underhand commerce as has been made by legitimate adventurers.

It is quite evident that, under all these adverse circumstances, the progress of the gold interests of British Guiana must be slow. But that the colony has before it a great future as a gold-producer I have no doubt, provided that the disputed country above mentioned is ultimately found to belong to Guiana. It is, in my judgment, this district that contains the bulk of the future riches. The colony thus far has attracted little outside capital to the development of its metalliferous resources, the Georgetown people having supplied the money, but so promising a field will not long be neglected. Some valuable information I give here as to the cost of production of gold is in the form of a quotation from a letter from the chief of a prospecting party which explored the country a year ago:

> These fields produce, in round figures, 110,000 ounces of gold per annum, of an average value of $17.50, to produce which about 10,000 men are employed at an average cost of $1.15 per day, exclusive of tools and transportation. It therefore costs $3,450,000 to produce less than $2,000,000. With the exception of one or two places, the gold is found in small patches which will not pay for the stripping, as one has usually to move from six to ten feet of waste ground to get one foot of pay gravel, and never more than 2½ feet. There is no chance for anything like hydraulic mining, and all ground worked at a profit must, from the nature of the country, be very rich. As

I have shown above, there is a great loss which must continue to increase as the nearer reaches are worked out and we have to go back towards Venezuela, which seems to me to be the principal source from which comes all the gold of this country.

In Dutch and French Guiana the same geological conditions obtain as in the British colony, and such surface deposits as have been worked have been developed by the slow and costly process of ground-sluicing. Considerable money has been invested in the mining industry in the two colonies, but each dollar's worth of gold extracted has cost double its value. The yearly output of Dutch Guiana runs from $500,000 to $750,000, while the French colony, in 1892, produced metal to the value of $800,000. In the latter place there has been considerable lode-mining, from which there have been good results, though the bulk of the yield has been taken from the placers. The effect of this has been to encourage the investment of French capital, and attempts on a considerable scale are being made to develop the lode-mining. It is not probable, however, that the contributions of any of the three Guianas to the world's stock of gold will ever reach a considerable volume. There is no silver in any of them.

BRAZIL.

The annual production of gold in Brazil is less than $500,000, having fallen off gradually since 1750, when the maximum output of $9,000,000 was recorded. All accessible placer-mines and surface lodes have long since been exhausted, and the geological features of the less-known interior are not such as to encourage hopes of the discovery of any rich deposits. At a distance of 3000 miles from the coast the surface is barely a thousand feet in the mean above sea level, and the land is covered with impenetrable jungle. The country as a whole presents less attraction for the adventurous prospector than any other South American state, and it is not probable that the present output will soon be materially increased. There is some deep lode-mining, in the well-known mines of San Juan del Rey and the Ouro Perto.

The proprietors of the former mine are now devoting attention to development work, thereby reducing for the time their output; the result of this work will probably be to restore the mine to its former position as a large producer, and it is likely to revive the glories of its name. Its main shaft is down 1100 feet, and its history has been remarkable for its continuity in depth. It is one of the deepest mines in South America, and its record is encouraging to many who, like myself, believe that the development of scientific deep mining in the country will give satisfactory results.

Most of the gold-ores of Brazil contain some silver, the proportion sometimes running as high as 20 per cent.; otherwise the production of silver is practically *nil.* The mining-laws differ little from those of surrounding countries. What is known as the "side-line" law obtains there, and mines are denounced and held under small annual payments. There is a plentiful supply of native and black labor, very good, and not expensive.

ARGENTINE.

That there is gold in Argentine is certain, but the attention of the people has been devoted almost entirely to agriculture and grazing, and it is difficult to forecast the development of mining. Some small placers in the southern part have been satisfactorily worked, and from time to time exaggerated reports of great discoveries reach the outside world. Lately a government official has been appointed to investigate the report that gold exists in paying quantities along the eastern slopes of the Andes. There is every reason, geologically speaking, to expect that Argentine will one day be a considerable producer of gold. Since the eastern half of Patagonia has been added to the country the mineral resources of the peninsula have attracted considerable attention, and auriferous sand in considerable quantities and quartz specimens rich in gold have been brought to Buenos Ayres and shipped to Europe. The character of these specimens indicate the presence in Patagonia of fairly powerful lodes. There is a small silver-mining industry along the foothills of the Andes.

It will complete the review of all the South American countries to say that Paraguay has practically no precious metals and that Uraguay has a few deposits of low-grade ore. The richest rock the country has produced mills under $5 to the ton, and the annual production of gold is about $7500.

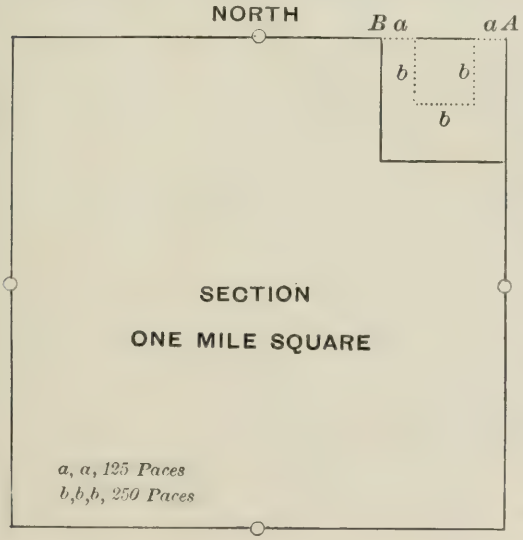
From this necessarily brief summary it will be seen that the total production of gold in South America is considerably less than $10,000,000 per annum,—less than a third as much as the output of South Africa. It will also be apparent that, except in certain inaccessible districts of Colombia and at the headwaters of the Amazon, surface deposits have practically been exhausted. New placer discoveries or alluvial deposits great in extent and rich in value are quite unlikely to be found; and the future of the gold industry depends upon patient, laborious, and scientific lode-mining with modern methods and machinery. The silver-product of the continent is something over $20,000,000 in value. Of this three-fourths come from Bolivia and more than one-third from one mine (the Huanchaca). It is unlikely, under existing conditions of production, that the low price of silver will have any material influence in reducing the output. The loss from such struggling mines as shut down and cease to contribute to the product will be offset by the increased production from the larger mines, which will be stimulated to a larger output to compensate for low prices.

THE NORTHERN WHITE-PINE INDUSTRY.

By Richard A. Parker, C. E.

FEW visitors to the World's Fair failed to be attracted by the novel exhibit made there of a Michigan logging-camp, including the enormous load of logs piled upon one sled. Many supposed the display to have been made wholly for advertising purposes, not thinking that what was there shown could be in any way typical of real life in the pine-forests. It must be admitted that the log-cabin was finished somewhat better than is common, and that the load of logs exhibited was larger than is usually hauled ; but the elements of truth were there, shown in many ways that were instructive to the visitor. The form of camp, the interior fittings, the meals served, the implements and tools of the logger, the sleds and railway-equipment are all to be found to-day in the bush, in every respect identical with those exhibited at the Fair. The load of logs there shown, containing over 36,000 feet (board measure), was hauled by one team almost a mile upon the regular ice-logging road of the Nestor estate, at Baraga, Michigan. It illustrated in a striking way the ease with which heavy loads may be hauled upon the ice.

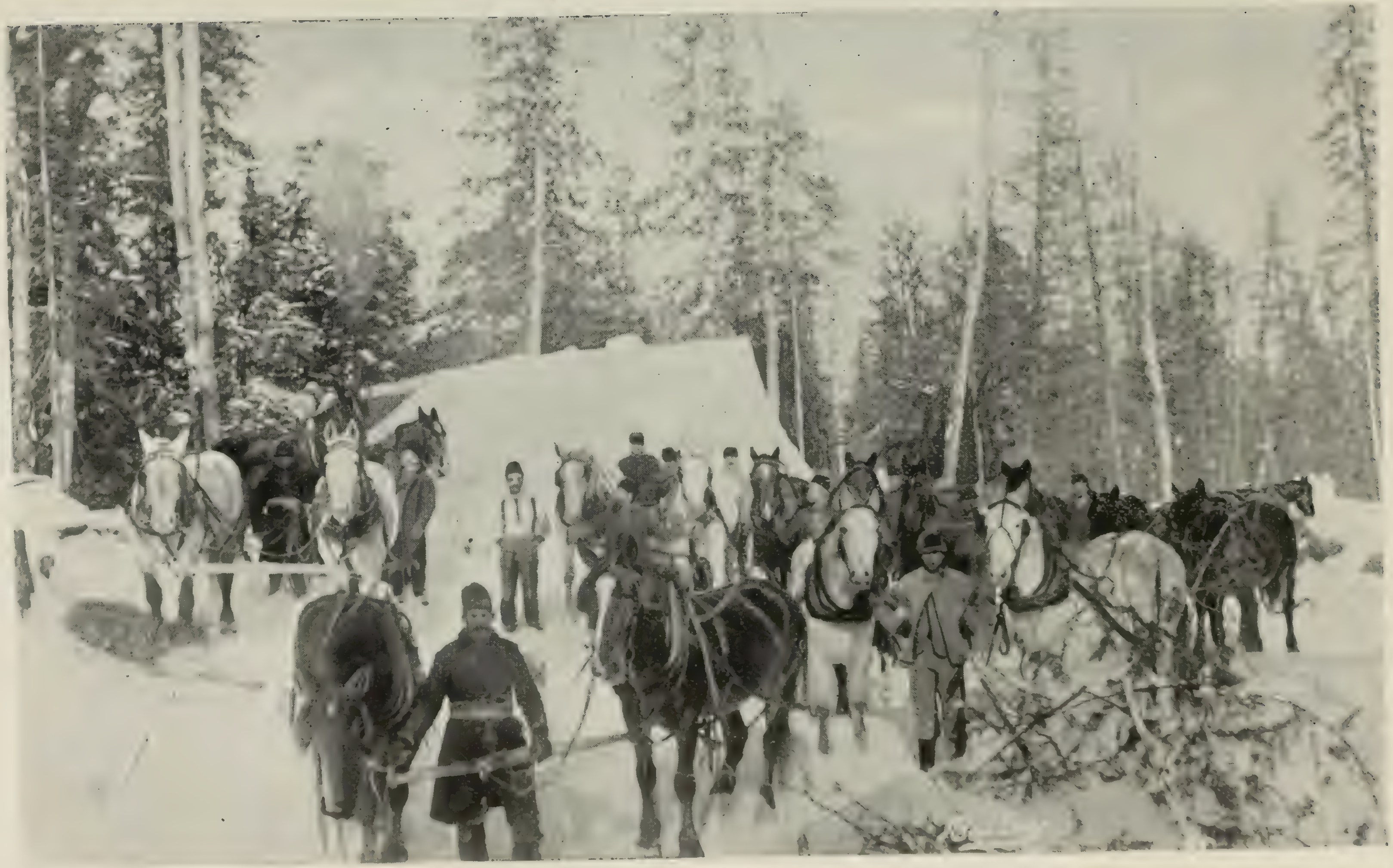
The same general conditions obtain in the lumber industry in the states of Michigan, Wisconsin, and Minnesota, which constitute the great sources of white pine in the northwest. The importance to the whole country of this industry, by reason of its volume and of the number of allied interests, is so great as to prompt the writer to offer to the readers of the Magazine some details of logging-camp life gained by personal investigation.



In the purchase of pine-timber land, the first step is the employment of a "cruiser" or land-looker, who estimates the number and size of the trees and notes the character of the land, course of streams, etc. With his camp-outfit on his back and a sun-compass as a guide, he makes his way through the pathless woods as easily and with as much assurance of safety as one would walk the streets of his native city. The land has already been subdivided by United States government surveyors into tracts one mile square, with posts marking the half-mile points. With this much to guide him the land-looker starts at the northeast corner of the tract to be estimated. [See *A* in the diagram.] Then, walking along the north boundary line toward the west for 125 paces, he counts the pine-trees, and estimates their contents in board measure; he then walks south 250 paces, estimating as before the pine-trees on each side of the course he is following; then west for the same distance; then north, to the north line of the land under examination; then west again for 125 paces. At the point now reached [*B* in the diagram] he will have completed the work deemed necessary to estimate the probable yield in feet (board measure) of a tract of land one-quarter of a mile square, containing forty acres. Each forty-acre tract is similarly estimated. When the trees are very numerous an acre is paced off, the trees counted, and their contents estimated; the whole area of closely-timbered land is then estimated, and in this manner a close approximation is obtained of the number and size of pine-logs the land will yield.

LOGGING HORSES ON PARADE.

A log twenty-six inches in diameter and sixteen feet long will cut 500 feet (board measure), and such a one is considered of exceptional size. Michigan has patches of timber that will cut three logs to the thousand feet, but they are small and isolated. Twenty-five years ago, when the cut of timber was coming mainly from the lower peninsula, it was not unusual to get logs that would run one and one-and-a-half to the thousand feet. They were known as "cork pine," of which

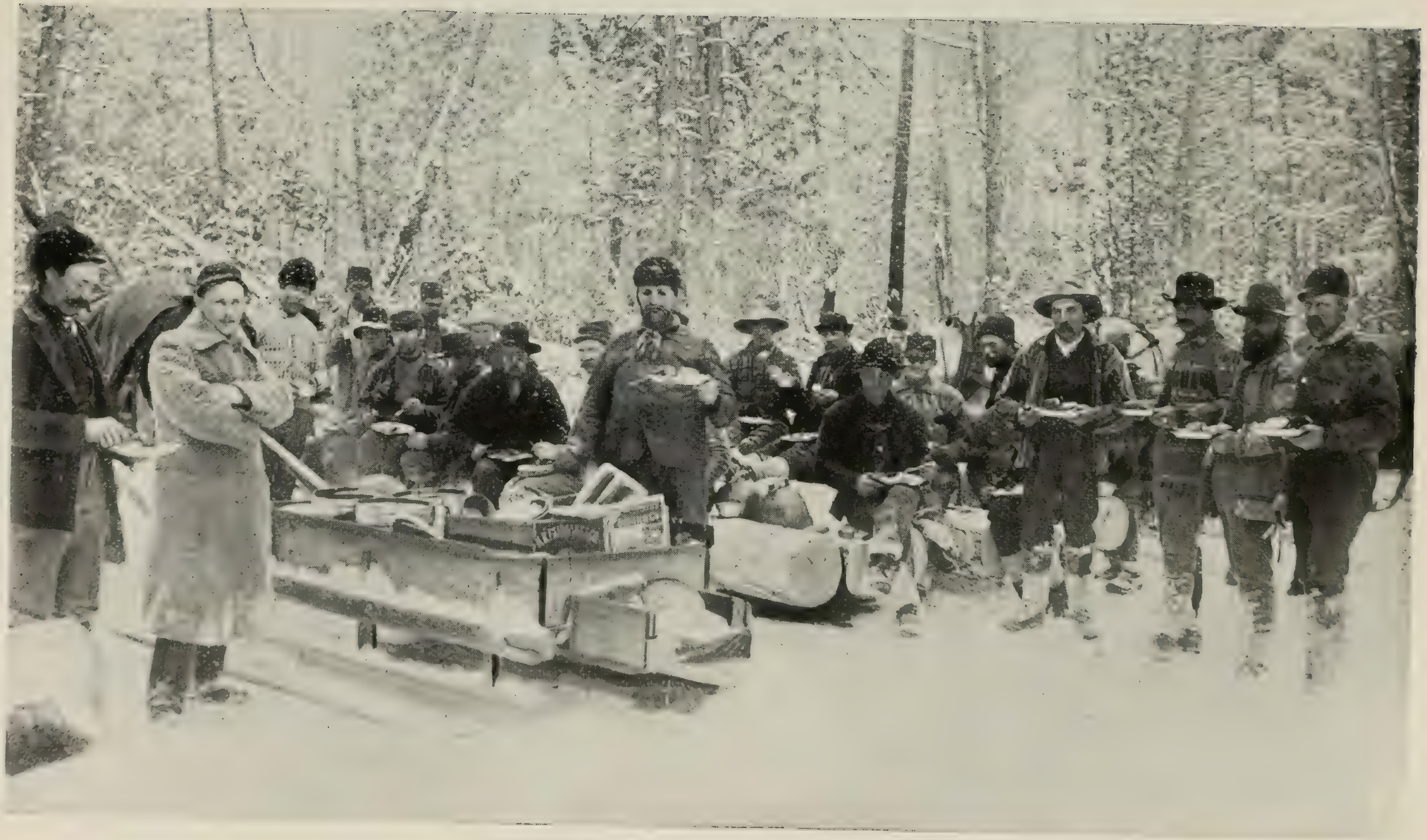


GOING TO WORK IN A MICHIGAN LOGGING-CAMP.

there are now few to be found standing. Some tracts of pine lands have been cut over three times, each cutting proving a commercial success. In Minnesota the white pine is not of the same uniformly good grade as that from Michigan, being smaller and somewhat more knotty. Logs there run from five to eleven to the thousand feet, while instances have been known of a lot of logs running even twenty-two to the thousand feet being sent to mill—the latter material yielding of course very small and inferior lumber. Northern Wisconsin logs are of as high grade as those of Michigan, being grown in practically the same timber area.

NOT AN UNCOMMON LOAD.

Stumpage, or the price at which the owner of the land will sell the standing pine, varies, as it is dependent on the quality of pine; that is, its freedom from shakes or knots; the size of logs; whether the trees are well bunched or badly scattered (this point involving the cost of hauling); and, finally, their proximity either to a railroad or to a stream upon which they may be "driven" (floated) to a mill. It is a strange fact that, in spite of the constant cutting of pine and its probable total exhaustion (if the present rate of cutting be maintained), the price of lumber has, for the past twelve years, remained practically at the same figure, while the price of pine stumpage has doubled. Lumber has ranged from $10.50 to $14.50 per thousand feet (board measure); while stumpage, which formerly ranged from $2.50 to nearly $5 per thousand, is now quoted at from $3 to $7. This is due largely to the increased extent of logging operations and



LUMBERMEN AT DINNER IN THE PINE-WOODS.

"SNAKING OUT" LOGS TO THE SKIDWAY.

greater facilities obtained through mechanical appliances, which reduce cost and effect a saving of the material. The day of a chopper swinging his axe into the heart of a soft pine, filling the wintry air with the music of falling chips, has given way in the last ten years to the humdrum of the two-handled cross-cut saw. This prosaic change effects a marked saving of lumber when the butt-log is sawed in the mill.

The felling of trees begins usually in the early fall and continues until winter has well set in. After felling, the trees are trimmed of their branches, cut into advantageous lengths of 12, 14, 16, or 20 feet each, and "tonged-out" by horse and chain to a skidding-place near the main logging-road. Here they are piled, one on top of another, into a rough pyramid, about twenty feet in height and of such length as the logs cut in the vicinity will permit. A sort of rough cribbed foundation is laid on the ground for the logs to rest upon.

With the advent of snow and cold weather, the logging-roads are laid out, "grubbed," and cleared away for a width of twenty feet, usually in the low-lying ground. When practicable, they are run over swamp-lands. The grade must be kept in favor of the loaded sleighs as much as possible. There are few keener pleasures than is afforded by a ride behind the headquarters team, with the reins in the superintendent's hands, over miles of these boulevards of ice. The roads are kept up at great expense. During the day men are constantly at work, leveling irregularities, and at night, when the weather is cold enough to freeze, the roads are thoroughly "sprinkled," so that by morning the sleighs glide easily over them, with their loads of from four to seven tons drawn by a single team.

An exceptionally large load of railroad-ties was recently hauled over one of these ice-roads. A special rack forty feet long was constructed, which the foreman began to load with ties two-and-a-half miles from the bunking-ground. When the load was completed the sled was still a mile from the bank. On that rack were piled 822 standard ties, in twenty-one tiers, and the weight was something less than forty short tons. A single team handled it, and delivered the load safely. The grade was down-hill somewhat, but of course very slightly so. These sleighs for hauling logs are massive, having a tread or track of five feet six inches, a width of ten feet, and a length of nine feet. At the outer ends of the cross-pieces iron teeth are inserted, which serve to keep the logs from rolling off until the binding-chains are in place and the load secured.

At times the roads leading from the skidding-places to the log-bank cannot avoid steep hills. With such loads as are usually drawn it would be dangerous to run them down-hill on the snow. The road is therefore made bare here and there, shovelfuls of snow being thrown where the runners will receive the benefit, and allow the load to partly slide and partly be drawn down-hill. When going up-hill, road-trimmers, jocularly called "snow-birds," throw on enough snow to permit the sleds to run freely. The sleds alone are a very heavy load for the team to draw up these hills. On the arrival of a load at the banking-ground, the logs are rolled off and piled in convenient places which have been prepared to receive them by laying logs at right angles to the

A SMALL BANK OF LOGS.

bank of the stream. When the logs are all delivered to the "bank," and the early spring thaws fill the streams, the driving begins, lasting usually through the four months succeeding April.

When the operations are extensive and the trees are closely grouped, sleds and ice-roads are replaced by regular logging locomotives and trains of flat-cars. The objection to them is that of initial outlay for plant, and the somewhat more expensive road that has to be built, as the road-bed is usually made upon solid ground, which costs for grading, ties, rails, etc., upon an average, $4000 per mile.

Steam-loggers have been tried, but without proving entirely satisfactory. They are in appearance not unlike some of the steam street-rollers, with large, wide-toothed wheels to obtain a grip upon the ice or snow ; but, owing to their weight, they are not as successful as the steam road-locomotive. Their tractive power is dependent upon their weight, which makes them clumsy and difficult to handle.

The log-drive, beginning with the spring freshets, presents many points of interest, with the rush of waters, falling and boiling along in their rocky channels, carrying the logs sometimes quietly and easily where the grade of the stream is light, and again throwing them up on end, side-wise, tumbling over and around each other, plunging as they go through a dam and over the apron into the pool beneath, to be carried onward to the mill. Occasionally the logs are stranded ; then the log, resting on the shore and reaching into the stream, with little difficulty persuades others to remain in its company, until very soon a jam is formed. With shoes provided with iron spikes, and with a long steel-pointed pole, the drivers walk on the round logs, as easily as on solid ground, to the jam. By lifting and prying with pevies,* they free the logs and allow the moving water to take up its burden and hurry it on to the loading-place or mill. When the jam cannot be thus readily broken, dynamite is often used with success ; but it is not resorted to except in extreme cases. The dexterity and agility of drivers are astonishing. Upon logs of all sizes, bobbing, floating and rolling, they walk, stand, and ride. The bucking broncho is a rocking-horse compared to these saw-logs with their treacherous antics. Tests of skill are at times attempted between expert drivers, by two of them getting upon one log and turning it rapidly by running, as a squirrel turns the wheel in his cage, when one contestant will attempt to check it, and thus throw the other driver into the water. Chill and frequent are the baths these men daily receive, often spending the entire day in the water that is fresh from a snow-bank. Owing to the short period of high water, their hours are very long ; indeed the hardest part of the

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* A logger's implement for turning or rolling logs, consisting of an iron-pointed wooden lever and an iron hook hinged at the end. R. A. P.

SOME PRETTY GOOD-SIZED LOGS.

life in lumber camps is that of driving, as the drivers are often at work by 4 o'clock in the morning and remain at it until they can see no longer at night.

The men in all the camps, cutting, hauling, and driving, are exceptionally well fed. The bill of fare is varied, and of excellent quality. Meats—fresh, salt, and smoked—are supplied in abundance; fish, vegetables, pickles, dried fruits, pie and cake of many kinds, with tea and coffee, are found upon every table. I lately chanced to see a bill of goods ordered which was intended to sustain a camp from the middle of February to the middle of April, and among the items were 2 tons of ham, 2 barrels of syrup, 10 barrels of corned beef, the same amount of pork,* 320 pounds of tea, 10 barrels of sugar, 1 ton of lard, 1 ton of butter, 100 pounds of coffee, 100 pounds of baking-powder, and 40 pounds of pepper. Such are the general store-items called for, for about 200 men. Prunes, raisins, currants, mince-meat, apples, etc., form the sweets that are part of the dinner and supper of each day, while such staples as potatoes, beans, and flour are distributed to the several camps in enormous quantities.

A COOK AND HELPER.

Having briefly followed the course of the log from the hillside to the mill or railroad, it may prove of interest to examine into the extent and value of the forest- and sawmill-products. In a United States census bulletin giving statistics of lumber-mills, sawmills, and timber-products of the white-pine states of Minnesota, Michigan, and Wisconsin for the last census year, the following extraordinary figures appear:

Value of forest produce not manufactured at mill	$ 30,426,194
Value of mill-products (lumber sawed)	115,699,004
Value of manufactures (staves, heading, lath, and shingles)	21,112,618
Total	$167,237,816

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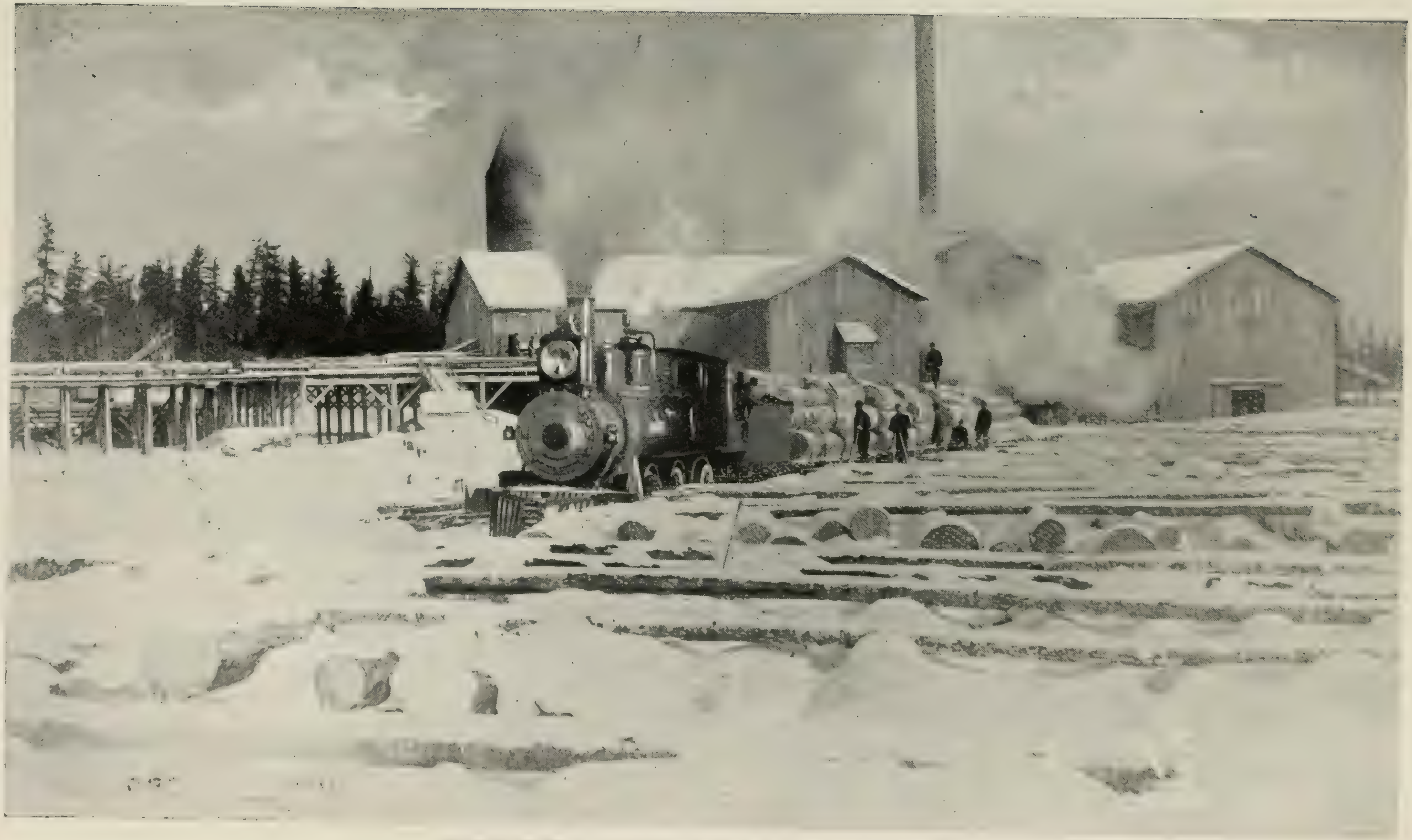
* Owing to the approach of soft or warm weather, this amount of salt meat is ordered, as fresh beef would not keep well enough, though quantities of the latter are sent in each week.



THE USE OF A LOCOMOTIVE IN A LOGGING-CAMP.

The production of this value required an investment of capital amounting to $270,152,012; the employment in the forest of 95,367 persons and 32,491 animals; the labor in the mills of 89,238 persons; the removal of 1,262,151,180 cubic feet of merchantable timber of natural growth; the investment of $7,890,254 in vessels, railways, and waterways, specially used in this industry for the transportation of its material and product; and, finally, the expenditure of $99,688,256 for wages, subsistence, supplies, and miscellaneous expenses. The ratio existing between the three white-pine states, involving the total value of mill-products and re-manufacture, is 7 for Michigan to 5 for Wisconsin and 2 for Minnesota, which figures closely approximate the relative importance of the industry in each of these states. In the census report the value of the pine stumpage consumed in the year 1890 is estimated at $13,100,043 for Michigan, $7,526,550 for Wisconsin, and $1,576,918 for Minnesota.

The production in 1890 of sawed lumber, not including shingles, staves, heading, and lathes, was:

For Michigan	4,311,240,000	feet	B. M.
For Wisconsin	2,861,517,000	"	"
For Minnesota	1,028,665,000	"	"
Total	8,201,422,000	"	"
[Total for Michigan for 1880	4,172,572,000	"	"]

If we assume a price of only $12.50 per thousand for the entire cut, its value in the census year 1890 was more than $100,000,000 in that one item, and, as there has been practically no difference in the amount cut in the state of Michigan between the two census years 1880 and 1890, it may be safely assumed that that state has produced annually for the past thirteen years over $50,000,000 worth of sawed lumber. The magnitude of these figures is startling to those who have not given the subject attention and are suddenly brought face to face with the importance and value of the industry.

The question naturally arises, how long can this enormous rate of cutting continue? The supply "which, a few years ago seemed so great that to attempt an accurate estimate was deemed too difficult an undertaking, has since then become reduced to such small proportions that the end of the whole supply in both Canada and the United States is now plainly in view."

In a recent report to the secretary of agriculture, the chief of the forestry division made the following statement: "The annual product of this pine from the sawmill has reached the enormous total of over 8,000,000,000 feet (board measure), which, if we assume a pine stumpage of 5000 feet to the acre—a high average—would require the cut-

SLEEPING BUNKS IN A LOGGING-CAMP.

ting of 1,600,000 acres annually of the white-pine supplies. Since the three white-pine states (Michigan, Wisconsin, and Minnesota) have a reported forest-area of altogether 60,000,000 acres, it is evident, that even if we allow-two-thirds of that area to be in the white-pine belt and consider this area fully stocked (which it is not), twenty-five years would suffice to practically exhaust the supplies. These figures, crude though they be, leave no doubt that the end of this staple is practically much nearer than we have supposed; all opinions to the contrary may be set down as ill-founded."

While it is true that we still have vast quantities of the red wood in the northwest states, its remoteness from market will always prevent its extended use in the middle and eastern states; the only solution to the problem of the future supplies of white pine lies in following the example of European nations which have made forest-growth a study for years, and now are reaping the benefit of their foresight. They control the cutting of the newer growths and reforest the cut areas. Owing to the fact that timber-lands are almost entirely owned by individuals in this country there can be no regulations as to the cutting; the scarcity of pine has not as yet driven any one into the business of forest-growth, though it can be demonstrated that it has the elements of success and, in certain localities where freedom from forest fires can be had, that it would pay if carried out upon a proper scale.

The three white pine states have enormous areas of land from which the pine has been cut and which has been found to be of poor quality for farming. The hard-wood lands yield a soil that is available for potatoes and the cereals. This cut pine land should be restocked and sown to pine. The owners of such lands should be induced to do so, as every tree planted and grown adds to the wealth of the state and nation. The legislatures of these states should enact laws which will foster and encourage such work, and should exempt from taxation, for a period sufficiently long to yield a fair-sized tree, say fifty years, all lands so cultivated. Should the lands subsequently be found to be mineral-bearing and produce mineral, then it would be only fair to so adjust the tax-exemption as to permit tax-collection upon such mineral-bearing areas.

The United States government has fostered the European idea of forest rehabilitation and has established a division of forestry under the department of agriculture. But the attempts made at planting pine-trees under its direction are isolated, and the results have been meager. In New England old fields or farms which are growing up to pine by spontaneous seeding are usually not allowed to grow to timber, being cut for box-boards when thirty to thirty-five years old.

It is distressing to think that the future holds no promise of a continuance of this wealth-producing resource, and that in a few years many who read this will wonder where the forest is that it was once deemed "impossible to accurately estimate." To be sure, we are getting to be a nation of users of iron and steel, rather than of wood, as the consumption of iron per capita has increased from 117 pounds, in 1885, to rather more than 300 pounds in 1890, the whole of which we produced in our own country; while the cut of pine has increased at a very much lower rate. It is self-evident that, as the stores of the latter diminish, we must husband them by drawing more heavily upon our mineral reserves.

AN UNSETTLED QUESTION IN VENTILATION.

By Leicester Allen, A. B., M. E.

WHETHER, in ventilating a crowded assembly-room, the air should be made to move upward or downward is still a matter of debate. For the credit of that branch of engineering devoted to heating and ventilation it is time this question was definitely settled. Whether the nature of the requirements for good ventilation demands that the entrance of fresh air should be at the bottom and the exit of vitiated air should be at the top, whether this method should be reversed, or whether a compromise between these two methods is better or worse than either used singly, ought to be positively decided, unless the obtaining of necessary experimental data be from the nature of things so difficult as to baffle scientific investigation,—a view which I, for one, am unwilling to entertain.

About three years ago the writer was called into consultation within a short interval by two different building committees, to assist in their decision upon the relative merits of proposals for ventilating two church-buildings designed by different architects. The heating and ventilating plans for one of these buildings provided for expulsion of air through openings in the ceiling of the auditorium, while those of the other building contemplated the removal of air through registers opening at or near the bottom of the room, and connected with specified ventilating ducts and flues. I was told that in each of these sets of plans the direction in which the air was to be moved in the space to be ventilated was determined in advance for the engineers who designed the different plans, the architects of the two buildings having respectively made the direction of movement a limiting condition in their requests for plans, specifications, and estimates. Each of the architects *knew* that the direction of movement he had prescribed *was right*, as I was informed in subsequent separate conversations with them. Each had performed experiments in buildings, and one had found uniformly more carbonic acid in the lower part of the rooms experimented in, while the other had always found more near the ceiling. The former accounted for the accumulation of carbonic acid near the floor by the greater specific gravity of carbonic acid as compared with air. The other was positive that the carbonic-acid gas, when issuing from the lungs in a crowded hall (being heated to the temperature of the blood), must be very nearly of the same specific gravity as that of the air into which it was expelled, and that, being mingled also with nitrogen at blood heat, the specific gravity of the mixture would be such as to cause it to be carried up to the ceiling by ascending currents of warm air; and, hence, that the results of his experiments were thus sufficiently accounted for. I asked him if he could point to an authority for the specific gravity of the mixed gases of exhalation at the temperature of expulsion, but he could not name any. As for the skin being an excretory organ which eliminates carbonic acid unmixed with free nitrogen and at a somewhat lower temperature than that of the breath, he seemed never to have heard of such a thing. Neither did he appear to have considered the possibilities of other emanations from the human body in health or disease. The contamination of the air by breathing appeared to be the only aspect of the subject he had considered. However, he rested with entire confidence on the soundness of his opinion.

The other architect was equally ready to maintain that his theory was correct, and that it adequately explained the alleged tendency of carbonic acid to collect in the lower part of a room containing an assembly. Among the arguments this gentleman used in support of his view, I remember that much was said about the accumulation of carbonic acid in wells, etc., the gas running into the wells and displacing the lighter air.

These samples of divergence in opinion are, I think, fair specimens of what may be met with, not only among architects but among others who have more or less studied ventilation. The object of this paper will be to point out what is lacking to a final settlement of this question, and to suggest experiments which must be performed in order to obtain the yet missing data. When these are supplied and the question is reconsidered in the light of additional knowledge, it may turn out that local conditions will determine which direction is best for any special case, and that these conditions may vary from time to time in the same building—and even in the same room—so as to render any absolute and invariable rule impracticable in its application.

Perhaps I ought to have said earlier that this question is principally important as it concerns ventilation through shafts by currents generated directly through the action of heat. When mechanical means are employed to force and control ventilation it may be made so positive and copious as to give good results under almost any set of conditions. Probably those who entertain positive opinions relative to upward or downward movement of air in rooms to be ventilated by heated currents in shafts base their views chiefly upon the assumptions that the removal of carbonic acid to an extent that maintains its percentage at a given low point is, in itself, all that is required for good ventilation, and that the removal of carbonic acid must be accompanied by that of all other noxious exhalations of whose presence carbonic acid is thought by many to be the sure and inseparable sign. I do not think that the act of removing the sign of the offending matters logically implies the removal of the offending matters also. However, the correctness of the assumptions in most cases will be generally admitted, but they cannot be correct for all cases and every set of conditions.

In the first place, noxious gases may be present that are not indicated by the simultaneous presence of an undue amount of carbonic acid, and are not introduced with the latter from the same source,—the lungs. Such was the case with the air in a school in Alpena, Michigan, recently described by Professor S. Dewey;* also in a case of a school, cited by Fred P. Smith,† where multitudes of flies, as well as quantities of fetid gases from closets, entered through ventilating-flues. Carbonic oxid may be escaping into the apartment from a leaky furnace or smoke-flue. Compounds of hydrogen or ammonia with sulphur may be present, together with other fetid vapors introduced from water-closets or defective soil-pipes. More or less contamination of the inclosed air may occur from the leaks in gas-pipes and gas-fixtures that permit unconsumed illuminating gas to enter apartments.

These gases are not all of the same specific gravity. Sulphuretted hydrogen, like carbonic acid, is heavier than air; while carbonic oxid, one of the deadliest of gases, and illuminating gas are much lighter than air. Here, then, we have two gases, both liable to be present in apartments, and both of a noxious character, whose tendency would be, under the action of gravity alone, to seek the ceiling instead of the floor. Unpleasant symptoms would be produced by a far less quantity of these gases than would be needed to make the presence of carbonic acid objectionable or even sensible through its effects upon the human system.

If gravity plays any important part in separating light gases from heavy ones the indication would be, from these facts, that the contaminated air should be taken partly from the top and partly from the bottom; because, if these gases remain unmingled with the inclosed air and find no exit at the top, some of the most noxious may rise and gradually accumulate at the top, filling the room in a downward direction till they reach a level where they are liable to be inhaled. On the other hand, carbonic acid, sulphuretted hydrogen, and phosphuretted hydrogen would seek the floor, and the region of purest air would lie between the floor and ceiling at some intermediate but indeterminate height. Unfortunately for the tenability of the theory that the heavy gases fall out of the lighter ones, it is a fact that all gases tend to mingle with each other in uniform mixtures; and this tendency is such that, if time be allowed for its action, not only will it overcome the resistance due to the difference of specific gravity, but it is also competent to overcome very much greater resistance.

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* In the *Pacific Builder*.

† In *Heating and Ventilation*.

If a jar containing hydrogen gas be inverted so that its mouth covers exactly the mouth of a similar-sized jar containing carbonic-acid gas, although hydrogen is twenty-two times lighter, bulk for bulk, the former will go down against the action of gravity, and the carbonic acid will go up into the upper jar, so that in a few moments the jars will be found to contain equal weights and equal volumes of hydrogen and carbonic acid. The experiment affords a striking illustration of the law of the diffusion of gases, because the extreme difference in the specific gravities tends strongly to keep the gases separate. Although there is far less difference between the specific gravity of air and carbonic acid, the same tendency to diffusion exists in a much greater degree when these gases are put into the same inclosure. If a jar be filled with carbonic acid, and a piece of pure elastic sheet-rubber be tied over the mouth of the jar, the lighter air will find its way into the inclosed gas, forcing its way through the very texture of the rubber diaphragm, and as the mixed air and carbonic acid cannot again pass through the membrane, the latter, if firmly and tightly fastened, will stretch and swell out as the air passes in, assuming a balloon-like form, or it may ultimately burst under the accumulating internal pressure.

We may reverse the experiment by tying the diaphragm over a jar filled with ordinary atmospheric air and placing the jar mouth downward, under a bell-glass inverted in mercury and filled with carbonic acid. When this is done the rubber membrane will be gradually pressed into the jar as the air passes out, and, unless torn under the rapidly accumulating pressure, it will be forced into the jar till it reaches the bottom. While there are no exceptions to this law of diffusion of gases, the rates at which the different gases diffuse into each other have not been determined. Until careful experiments have determined the time required for different gases to permeate definite volumes of other gases some of the questions relating to the art of ventilation cannot be authoritatively answered.

Some who have endeavored to study the question whether upward or downward movement is the better for ventilation have adopted a method of experiment which seems to me incapable of determining anything of value as regards a real solution of the problem. The method referred to is the generation of smoke in a closed room to ascertain whether it will rise or fall. One experimenter, of high reputation as an expert in ventilation, smoked a pipe in a room containing still air and assumed that the movement of the smoke, which was upward, was an indication of the direction and the rate of the motion of other constituents of the breath diffused into the contained air. That conclusions derived from such experiments are likely to be utterly misleading will appear when the above experiments in diffusion are considered in connection with the fact that there is not the slightest resemblance or analogy between visible smoke of any kind and a gas, properly so called. Anything that renders the air in the least opaque is not a gas. Visible smoke consists of minute solid particles diffused in the air, the action of which differs entirely from that of a gas flowing into any other gaseous body. Every gas possesses expansive force which tends to separate its particles as widely as possible, and if there be no restraining force, such as the walls of an inclosure through which they cannot pass, there is no limit to this expansion. In thus separating, the molecules of the gas move freely through bodies of other gases into which it may be injected ; but, as this motion of expansion sets up in every possible direction, it can cause no current in one direction more than in another. The gas while diffusing may, however, be carried along by previously existing currents or restrained from moving in any direction by an obstruction.

There can be no doubt that the temperature of any gas issuing into an apartment, as well as its specific gravity, has a temporary effect upon its tendency to rise or fall. If the gas be warmer than the air into which it issues, and if its specific gravity be less than air, these conditions will co-act to make it rise. If its temperature be less and its specific gravity be also less, these two conditions oppose each other in their effects upon the direction the entering gas will take, and it will not rise at all, or will rise more slowly than in the first instance. If its temperature be colder than the air and its specific gravity greater the conditions will co-act to make it fall toward the floor. Finally, if the specific gravity be greater than air, and its temperature be warmer, we have again opposed conditions ; the gas may remain temporarily near the point of ingress, it may rise or fall according as one or the other condition preponderates, or it may be borne along by currents, its natural tendency to move in either direction being thus overcome. But its tendency to expand in all directions will be influenced neither by its specific gravity, nor by its temperature, nor by preëxisting currents, with the single exception that the higher its temperature is the more rapidly will it expand and diffuse. It seems plain that, if the rate of expansion of one gas into another be greater than the rate of flow of any existing current, the entering gas will move in an opposite direction to that of the current, and in such a case the current will not be competent to wholly expel it from any part of the inclosed space. And if it be specifically lighter or heavier than air its mixture with air will be correspondingly lighter or heavier than air, and it will accumulate accordingly at either the top or the bottom of any space into which it enters. But if the rate of diffusion be less than the rate of flow in the purging current the gas must be carried along, notwithstanding its tendency to diffuse in an opposite direction, and in such a case there could be no accumulation.

To secure perfect ventilation the rate of diffusion of the noxious gases must be somewhat less than the rate of flow of air through the inclosure. In many buildings manufacturing operations are carried on that give rise to deleterious gases and effluvia, and this question becomes of great importance in considering the best means of ventilating factories and shops in which large numbers of operatives are employed. It is admitted by eminent investigators and authorities that in assembly-rooms, hospitals, factories, etc., it is not the carbonic acid generated by breathing that is to be dreaded so much as the other noxious gases and effluvia which the presence of carbonic acid in excess indicates and measures. But in a room lighted or heated by gas there may often be an excess of carbonic acid without excess of other gases. Only under certain conditions, wherein the presence of carbonic acid in excess is known to be caused by exhalation, can it be a true measure of the presence of objectionable substances. How could this standard be employed to determine the presence of carbonic oxid issuing from defective heating apparatus, which gas has no smell and which is not a product of respiration? How could it determine qualitatively or quantitatively the presence of sulphuretted hydrogen, phosphuretted hydrogen, or illuminating gas? Yet all these may be present, sometimes in so small quantity as not to be separately distinguishable by smell, although other effects might be very perceptible. And unless their presence be determined by other tests than the presence of carbonic acid the sanitary engineer has no guide to the true source of contamination.

There is yet something to be learned in the art of ventilation through the experimental acquisition of new facts. If, in some of the laboratories of technical and scientific institutions, experiments directed to determine rates of diffusion of different gases that may be present in occupied rooms could be carried out, and if data could be supplied as satisfactory as have been furnished upon many other important points relating to heating, ventilation, and refrigeration by such institutions as Cornell University and the Stevens Institute of Technology, all unsettled questions in ventilation might soon be answered definitely and authoritatively.

THE KITE AS A LIFE-SAVER AT SEA.

By J. Woodbridge Davis.

THE life-saving kite, as some witnesses of its performances have called it, was designed originally as a huge plaything. It had an extensive surface to gather a great power from the wind ; it was strong and durable so that it might be used many times ; it was necessarily foldable for transportation and carriage through hatchways ; and it was rigged in such manner that its motions in mid-air might be compelled and guided from the ground. The problem of designing it proved to be interesting. It was found that, corresponding to a package of given length representing the folded kite, the maximum spread of surface could be obtained by making the three ribs equal, pivoting them together through the middle of each, and spreading them so that the six angles formed should all be equal. Hence would follow a hexagonal kite ; but as a plane with sharp, salient angles flies steadier and the covering material stretches tighter, so the binding-cord is drawn in between the sticks and the kite becomes a regular six-pointed star.

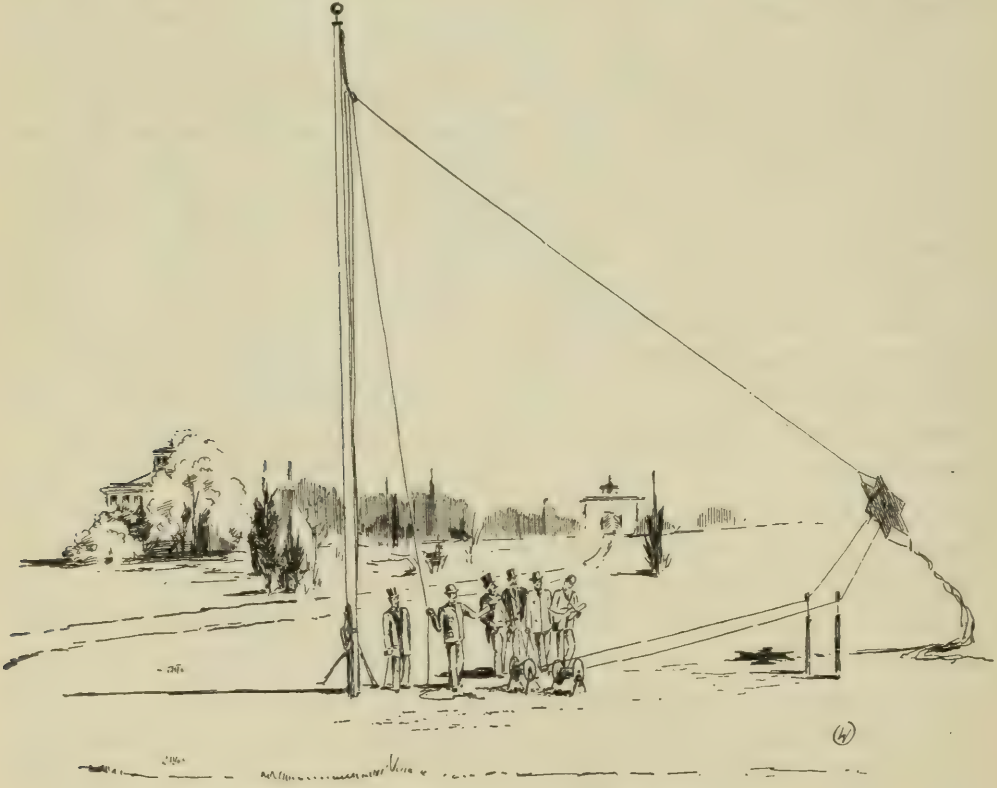
The most difficult problem was the designing of the sticks for maximum lightness and strength. The distribution of wind-pressure upon each stick, as received directly along its length from the covering, and indirectly to the stick's ends through the intermediation of the perimetral binding-cord, being determined, and the opposing strains in the six bridle-strings, known to be the total wind-pressure equally divided, being considered, the bending and shearing forces at every tenth of a semistick were ascertained, with the wind-velocity, size of kite, and position of bridle-strings represented in the formulæ by symbols but left undetermined in value. As the strength of the framework depended much upon the position of the bridles, the position was treated as variable, and the best value deduced, which thus became a numerical constant.

A feature of the discussion was the introduction of a variable safety factor. In a light breeze we can add little to the strength at the expense of buoyancy, but, so rapidly does the supporting power increase with the wind's velocity and so necessary does a greater safety margin then become, we both can and should, in the new condition, give a superabundant strength to the framework. An economical safety factor was found by experiment for a forty-mile wind, and made to vary from this value as the cube-root of the wind's velocity varies, and this was incorporated in a formula suitable for designing a kite of any size for any wind. According to this formula, a seven-foot kite, weighing six pounds, will safely bear a strain of 250 pounds; then, if the dictum of authorities be true that the tension between a team of horses and a ton of hay on the level part of an ordinary country road is 100 pounds, this kite will drag a train of tons along a level boulevard, or cause a canal-boat to glide through its narrow water-way with all the mules aboard.

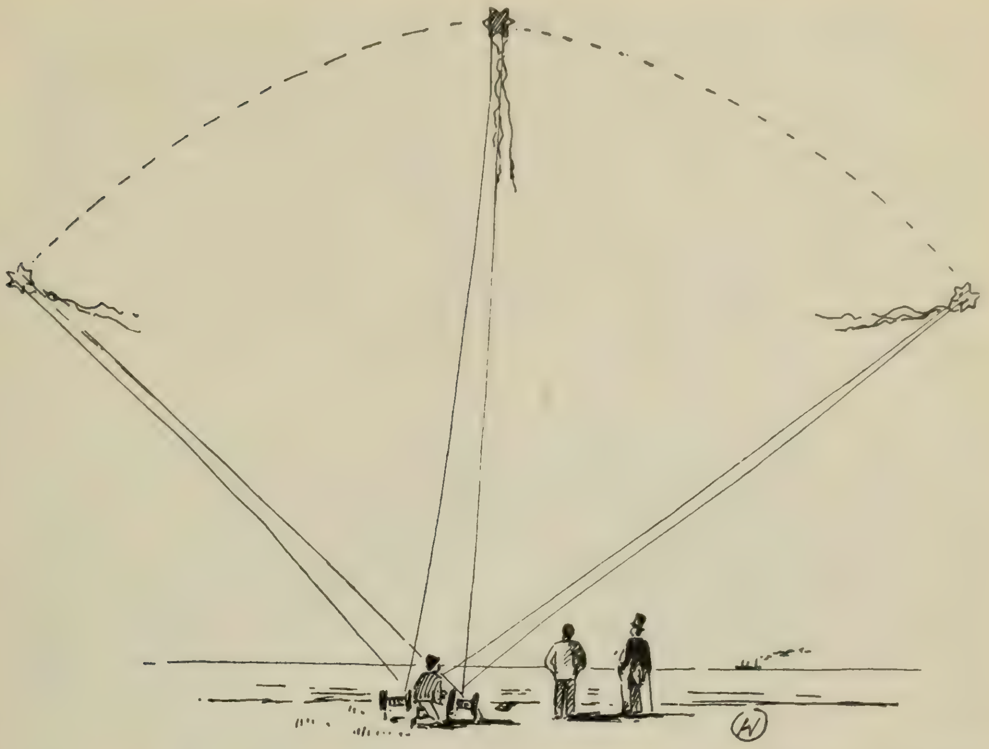
A problem not to be solved by calculation was to find the fittest material for the wind-surface. Many stuffs in the market were tried, unoiled and oiled. The former allowed more or less air to blow through, and the latter were either too fragile or too heavy and stiff. Alpacas and other materials never before oiled were put through the process until a fabric was found, light, strong, and pliable under the oiling, so that now the kite can be folded as neatly as a silk umbrella. It requires three weeks to make the cover—as long as to make a fisherman's sou'wester—both being made by the same process and in the same factory.

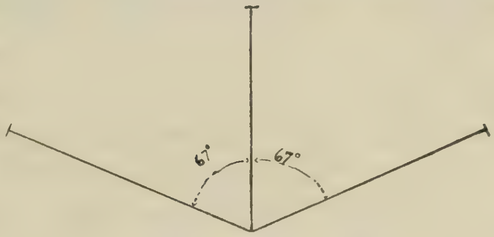
The kite's tail is made of clothes-line, hung on in four or five 100-feet lengths. When the kite whisks its tail in a high wind, the way it whistles and shrieks and snaps is terrible to hear.

The kite is managed with two lines which are used like reins in



RAISING THE KITE WITH A TOP-LINE.



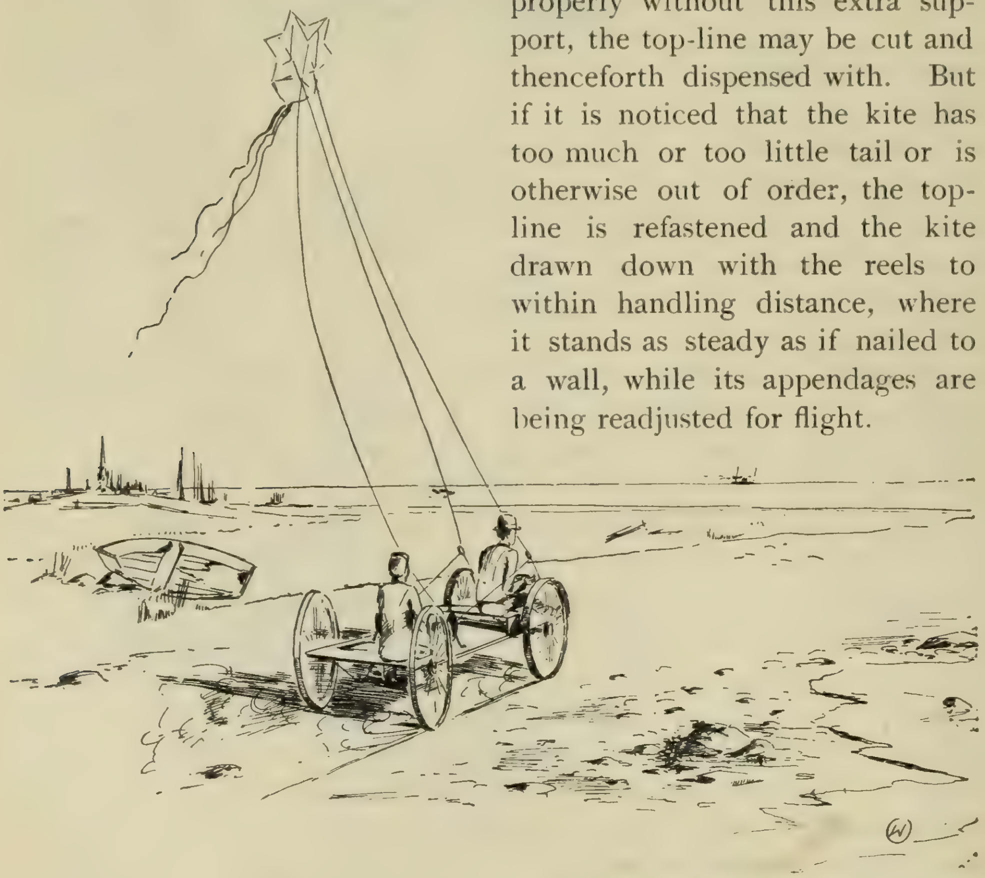


LATERAL DEFLECTION.

driving, and with the same effect. On the right side of kite three strings are fastened to the three sticks in a vertical row, and brought together to a grommet to which the right-hand flying-line is attached. The same arrangement exists independently on the left. A top-line is also used as an auxiliary in raising the kite. It is a light, strong line, such as is employed by masons in lining up walls, and is attached to a band connecting the two top points of the kite.

The outfit is put in service thus: If on a lawn, two stakes four feet high with pulleys lashed to their tops are driven eight or ten feet apart in a line perpendicular to the wind. A few yards to windward two reels, containing the two flying-lines and provided with ratchets and band-brakes, are pegged down close enough together to be worked by one man, each facing one of the stakes. The kite is carried to leeward and spread, which involves simply the labor of tying four points of the cover to the ends of two ribs, the third rib being already attached when folded. The flying-lines are carried from the reels through the pulleys on the stakes, which act as fair leaders to, and attached to, the bridles on the right and left sides of the kite; the tail is hung on and the kite let go.

But a more interesting and efficient way of raising the kite is by means of a top-line and flag-staff, the latter standing close beside the reels. A pulley is lashed to the halyards; through this is run the top-line, from a ball wound on a stick and played out from the hands, to the top-band of the kite. Then the pulley is hauled aloft and all is ready. The kite now can be put in flight from immediately in front of the stakes, and by one person. While the kite lies on its face a few feet to leeward of the stakes, the operator winds in the slack of the flying-lines and clamps the reels. Then he lays hold of the top-line and hauls in enough to lift the kite six or eight feet from the ground, and fastens the top line so to a cleat. The kite is held as in a vise by the two flying-lines and the top-line acting like guy-lines against the wind's pressure. The operator returns to the reels and lets out the lines by using either the cranks or band-brakes. The kite rises in the arc of a circle whose center is the pulley at top of staff and whose radius is the length of top-line. So easily and safely can this be done that it is a pleasure to haul in and let out the kite with the top-line fixed. Next the reels are clamped and the top line slacked; if the kite behaves properly without this extra support, the top-line may be cut and thenceforth dispensed with. But if it is noticed that the kite has too much or too little tail or is otherwise out of order, the top-line is refastened and the kite drawn down with the reels to within handling distance, where it stands as steady as if nailed to a wall, while its appendages are being readjusted for flight.



A KITE MOTOR.

AN UNCAPSIZABLE SAILBOAT.

To fly the kite and feel it tug like a wild horse, yet see it gracefully sweep and sway in obedience to the impulses sent aloft from the reels, and to hear the occasional swish of its tail, is exhilarating sport. Wheel in the right-hand line and the kite moves steadily yet swiftly to the right far off the wind ; cease winding, and the kite stands still ; persevere and it progresses until it has described three-fourths of a right angle from the leeward point. As it moves, it gradually descends and as gradually inclines its head to windward, the tail streaming out behind. At the extreme deflection the axial line of kite and tail seem nearly parallel to the horizon. Release the right-hand line, and back the kite rises to its summit, and on it sweeps to the leftward quarter, until its axial line is parallel to another horizon, having turned its head through many degrees so as always to point windward, while its path has been a rainbow whose span is three-fourths of the leeward half of the heavens.

To compel the kite to trace any curve in the air, the top-line must be used, and the bridles must be arranged so that the top and bottom strings are equal in length ; in other words, so that the kite may have no slant, but be at right angles to the flying-lines. Without the top-line the kite cannot now be raised ; with the top-line it can be raised, with or without the staff. When in flight, the top-line should be removed from the pulley by hauling the latter down the staff, cutting out the line, and retying it. Clamp the flying-reels and use the top-line alone. Haul in, and the kite rises almost overhead, gradually losing its power of pulling; pay out, and the kite sinks until its tail touches the ground, describing a vertical arc at any point of which it may be held stationary. Its pulling power increases as it descends; the strain in the top-line is always small. Leave the left reel clamped; work the other with the right hand and the top-line with the left; the kite can now be made to dart hither and thither in all directions, tracing the letters of the alphabet or any prescribed figure. In one experiment a row-boat was sent out from an island and stationed forty or fifty degrees away from the direction of the leeward point; the kite was then directed over the boat and lowered; a message was pinned to the tail, which the kite whisked instantly to another place. This maneuver was rapidly executed.

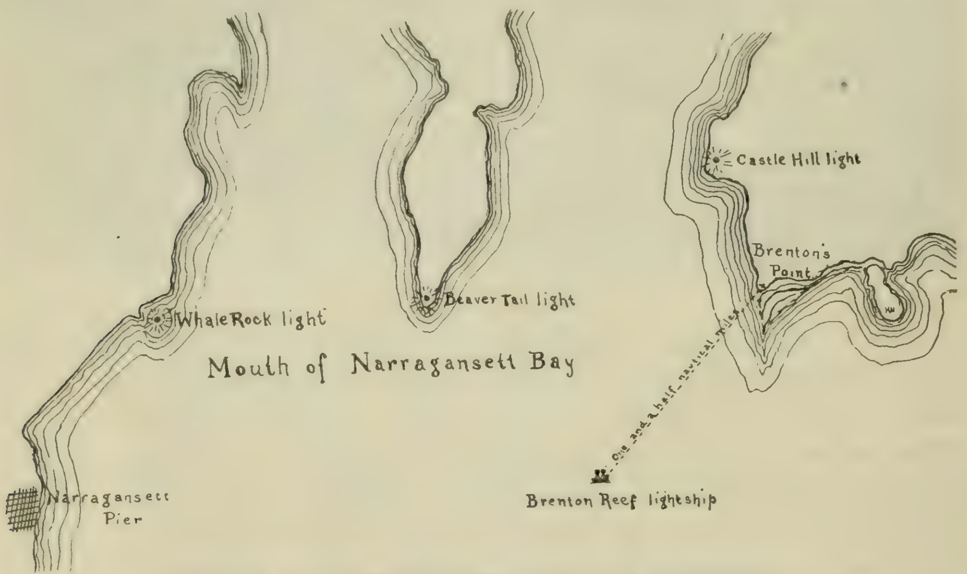


CHART OF THE BRENTON REEF LIFE-LINE EXPERIMENT.

The propelling power of the kite was exhibited at Arverne, Long Island, in the summer of 1892, where two young gentlemen from New York applied it to a wagon constructed for the purpose from special designs. Its platform is low and wide; all the wheels are of the same size—3′ 4″ in diameter—and strongly made; the track it leaves in the mud gages 4′ 8″. One passenger sits in the rear on a long low, seat so that he can slide his weight to windward when the kite is pulling abeam. His feet are deposited in a long well and thus keep the center of gravity near the ground. At his right and left are the two flying-reels in easy reach. Since one may be kept clamped, he can easily direct the kite with one hand. To his position comes also the top-line, which he can fasten to a cleat or manipulate as he will. The passenger in front acts as the pilot. His seat is a little more elevated, and he can shift to windward also. His business is to work the horizontal pilot-wheel connected by vertical shaft with the front axle, and to apply the brakes to the rear wheels. The flying-lines from the reels come forward, each on its own side of wagon, and leave the vehicle through pulleys lashed to the side-rails near the front wheels, over which are guards to prevent abrasion of the lines. The wagon has also adjustable shafts to be applied for horse traction. These young men had no trouble in propelling themselves, even with summer winds, with a seven-foot kite along the sandy beach. The kite can be directed 45 degrees off the wind and the wagon steered 45 degrees further to windward, so that, with a breeze blowing directly in shore or off shore, the wagon can be made to travel up and down the beach. The top-line is never cut loose, as it is very serviceable. It prevents the kite from falling in a sudden drop of wind; it enables the operator to lower the kite to obtain the full force of the breeze, or to raise the kite almost overhead when it is desirable to slack the speed or stop the wagon. Afterward a ten-foot kite was constructed for this wagon, but it has not yet been used. It is planned to employ the kite in the near future upon a large deep-keeled canoe, with a similar disposition of apparatus.

The remarkable tractional and steering powers of the kite led to its

RAISING FROM SHIPBOARD.

trial in carrying out life-lines. A mile of rope was wound on a reel and carried to South Brother island. A loop was made in the forward end, and twenty feet back of this was attached a 32-pound wooden buoy. A seven-foot kite was raised. When about 400 feet had run out, the flying-lines were cut. One was immediately fastened to the loop at the end of the mile rope; the other was also fastened there after being drawn in so as to direct the kite to a pier on Riker's island, five-eighths of a mile distant and not directly to leeward. Then the kite was let go, and the buoy was dragged down the beach and went scudding through the water at a rapid pace, dashing the foam about it. At times it jumped like a porpoise eight feet out of water, and took forward leaps of fifteen feet. It was dragged over a reef near Riker's, and finally to the shore of that island.

TESTING THE TAIL.

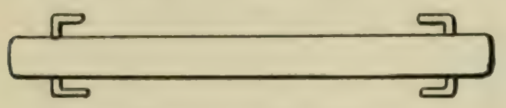
The function of the buoy is apparent in this experiment. While the kite was at full speed, its lifting power diminished and it simply towed the buoy and line; when the speed was checked by the meeting of obstructions, and finally by the friction on the long line, the buoyant power increased, and the buoy was lifted over the obstructions, and, toward the end of the course, kept constantly suspended a short distance above the water. But, had there been no buoy, the kite would have carried up into the sky, out of reach and use,—a quarter-mile of line all wasted. A strong tide was sweeping through the channel at right angles to the life-line, bearing it down-stream in a great curve; yet it seemed to have no effect upon the direct course taken by the kite and buoy.

The next endeavor was to try the kite on shipboard. But to charter a vessel and engage a crew expressly for the purpose of putting them within a mile of a lee-shore in a storm was out of the question. Therefore permission was sought to install the apparatus upon a light-ship, that at Brenton Reef being selected as being the closest in shore. Nevertheless it is 1½ nautical miles from the nearest land, the tip of Brenton's Point, and slightly farther from Beaver Tail, and several miles from any other shore. The task here set for the kite to perform was rather more difficult than is likely to occur in any case of shipwreck. The kite was required, in spite of the strong tides that sweep in and out of Narragansett bay, to carry a serviceable line 1½ miles to either of two points thrust out like fingers—to miss which would mean failure—with the wind perhaps not blowing directly toward either. Permission was heartily granted by the lighthouse board, although one of the members good-naturedly remarked that it would look like a long way from Brenton's light-ship to the shore.

After a three-days' wait for wind aboard a fresh breeze sprang up on the forenoon of the fourth from N.N.E., blowing off shore. The tide was about slack low. The stern of the ship was to leeward. The kite could not be sent toward land, but it was well enough in a first experiment to send it to sea. The trial was deferred until the crew had filled and trimmed the lamps and put the ship in order for the day. Then all hands from captain to cook collected to take part in the experiment. The life-line reel, which in this case carries two miles of manila rope, ¼ inch diameter, tested to bear 750 pounds strain, was faced to leeward, nailed down, and a buoy slung to the life-

AIMING THE KITE.

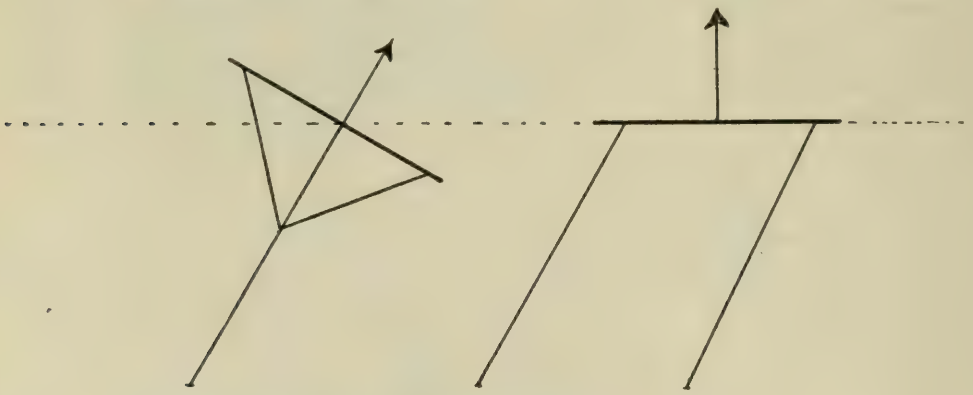
line. The flying-reels were nailed down side by side near the stern, the fair leading pulleys attached to the reels themselves. A seven-foot kite was brought on deck and spread, and the flying-lines separately tied to the two bridles on the right and left of the kite. Three sections of tail-rope were fastened to the tail-band. The top-line was rove through a small pulley and then tied to the top-band. The pulley was hauled up on the flag-halyards and the halyards wrapped around the mast cleat. A man held the kite at the rail, the pressure being taken up by the taut flying-lines. At the word the top-line was hauled in about five feet, hoisting the kite, and the flying-lines were paid out. Instantly the kite was sailing above the level of the masthead. The top-line was slacked, and it was noticed that the tail was too heavy. The kite was drawn in, supported by the top-line, and a portion of the tail cut off. It was launched again as before and found to be self-supporting when the top-line was slackened.



A STEERING IMPLEMENT.

The experiment of taking in and letting out the kite was tried repeatedly. It was surprising how easily this could be done. The top-line steadied the kite on the same principle as the tail, besides supporting it until it could be made self-supporting. The flying-lines steadied the kite laterally like guy-lines, besides steering it so that it could be accurately and steadily drawn in or let out through a space in the rigging scarcely wider than itself.

The accompanying diagram shows why a two-line kite is steadier, even when flown straight to leeward, than a single-line kite. The pressure of the wind is always normal to the surface. When the single-line kite is deflected from the wind this pressure does not tend to bring it back; it is feebly urged backward by the wind-pressure on the mere edge; hence it wobbles. When the two-line kite is deflected it is forcibly pushed back and held firmly in position with the full vigor of the wind. It seems as easy to project the kite by means of



the pair of reins through a narrow gap in the rigging as it is for a man to walk through an open doorway.

The life line was sent out as follows: The kite was launched by means of the top-line, this was cut and allowed to slip free, and the flying-lines to play out about four hundred feet. Then these were cut and fastened to the loop in the end of the life-line. The kite was deflected 40 degrees off the wind by shortening one line. This was effected by winding the line about the instrument shown in the sketch, consisting of a stick with a double hook at each end. The aim could be taken with the greatest nicety by means of this device. The buoy was passed overboard, and the line ran out about a quarter of a mile, persevering in the course laid out for it. There it was checked while under rapid headway, the line drawn in, and the keeper placed in command.

SENDING A LIFE-LINE ASHORE.

He directed the kite straight to leeward and sent the line out a mile to sea in eighteen minutes, the line being marked with a leather tag at each quarter-mile. The first quarter ran out in two minutes, although two men were braking the reel with staves. The second quarter was not timed, as we stopped the line to try its pull, which was more than one man could hold. The third quarter ran out in 4½ minutes, and the fourth in eight minutes. Whenever the line was

PASSING A HAWSER FROM SHIP TO SHIP.

checked the kite immediately lifted the buoy fifty or sixty feet out of water, and dropped it again as soon as it resumed its headway. The same effect would be produced by obstructions, such as floating spars, reefs, and bars.

The sailors were delighted with the working of the kite, and their respect for it rose as they realized its power. The art of managing it they had instinctively learned the moment they had seen it harnessed on the deck. There, a mile away—a speck on the horizon, with the buoy a black dot bobbing in the air beneath—it was pulling like a horse, keeping the line exactly on the surface of the water as far as the glass could follow. As a barkentine came heading in from the south'ard, the sailors hauled away to save the line; but, seeing she would miss it, let the kite run out again to puzzle the stranger. The crew was gratified to learn that the apparatus belonged to the lighthouse department, and expressed the wish that it might not be taken from their ship.

When the kite had been hauled in flying to the deck, it was next seized and thrown over the ship's side into the water. By hauling on the lines it was raised and put in flight. It was found that this could be done with the flying-lines alone without the top-line by hauling on one only, which raised the kite partly and allowed the wind to sweep under it and lift it out of the water and put it in flight. The operation of the apparatus seemed so simple and certain that the keeper said he had no doubt he could land the line on Brenton's Point or Beaver Tail with a southerly wind, an auxiliary kite being fastened to the lifeline a half-mile behind the first.

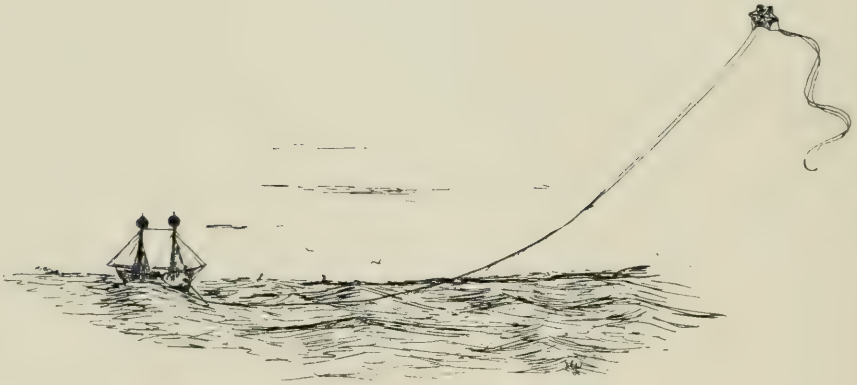
It is useless to make an appointment with the wind. An appointment was made for the wind to blow from the southwest on April 22, 1893, and a number of persons were invited to see the life-line come ashore. Sure enough the southwest storm-signal was flying over the custom house at Newport, and there was apprehension that the light-ship could not be reached. Several newspaper-men and other people drove down to Brenton's Point, and the neighboring life-saving crew turned out to watch for the incoming kite and line. But the wind was faint and the kite could not be cut from its top-line. So the kite-flier was reluctantly obliged to give over the trial, and bid adieu to the stationary mariners who trim lamps instead of sails and hang forever in the doldrums whether it blows or not.

The next day the wind did blow, and the crew hitched a kite to the end of the life-line, steered it carefully for a house on the tip of Brenton's Point, and let it go. To insure success they hooked on another kite half a mile behind the first, and had the satisfaction of seeing the forward kite go straight to its mark through the strong cross current of an ebbing tide. But not a soul was there ashore to note its coming or to detach the kite and buoy. So a boat was manned and sent after it, and the buoy was found beached some twenty yards to eastward of its aim.

In the bows of the ship lay a great pile of five-inch hawser, 200 fathoms long. As this was measured, marks were left at every fifty fathoms. The hawser weighed a ton. When it was suggested to fly the kite with this hawser, the captain was not amazed. The object of such an experiment was to determine the possibility of sending a towing line from a rescuing vessel to a disabled ship at sea, which in heavy weather is now an exceedingly difficult and dangerous proceeding.

On June 23, reports the captain, at 9 A. M., with a twenty-five mile breeze from the north, and a strong flood-tide from the south, a kite was sent out attached to the end of the hawser, without a buoy. The kite took the hawser off the deck itself, and towed out in 12½ minutes against the tide the entire 200 fathoms. The first mark went over the rail in 2½ minutes, the second in 3, the third in 3, and the fourth in 4 minutes. When the line stopped paying out it seemed for a moment to leap clear of the water. The pull of the kite was so great that six men were required to do some hard tugging to haul it back to the ship. The captain expressed the opinion that in a forty-mile breeze there were not men enough on board to haul in the kite and cable. Thus it was shown that a hawser can be quickly passed from ship to ship without hazard to either crew. In such real service, the labor of hauling back the kite in flight would not occur.

That a seven-foot kite could make such a strong pull against six men, the men pulling with the tide and the kite against it, seemed at first as unexplainable as it was unexpected. But the men hauled in by hand; it was heave, and then stop to get a new hold; the kite never stopped and never relinquished its hold. If the men spent two seconds to heave and six to get the next hold, during the latter interval the kite was unopposed in its work of overcoming the shipward momentum of the cable and impressing upon it a seaward momentum, and in the next two seconds the men encountered not only the present pulling of the kite but the adverse momentum of a ton of rope. At each new grasping the men found the cable running from them, not to a degree perceivable in motion, but noticeable in antagonistic power; if there had been no kite attached they would have found the line not obstinate but consenting. However, the animate prevailed over the inanimate; the kite was drawn to deck and laid away pinioned in its chest, thus ending what was to these sailors a memorable tug of war.



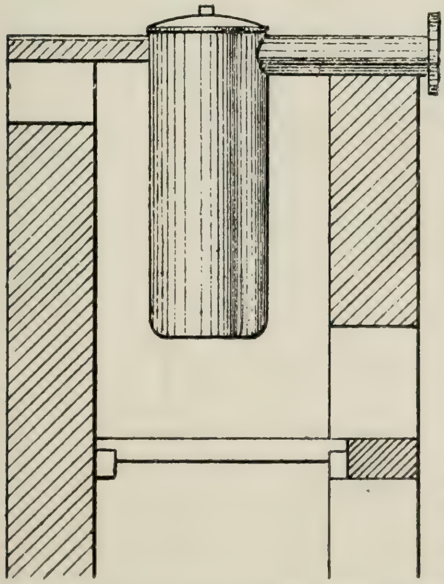
A TUG OF WAR.

COAL-GAS AND WATER-GAS COMPARED.

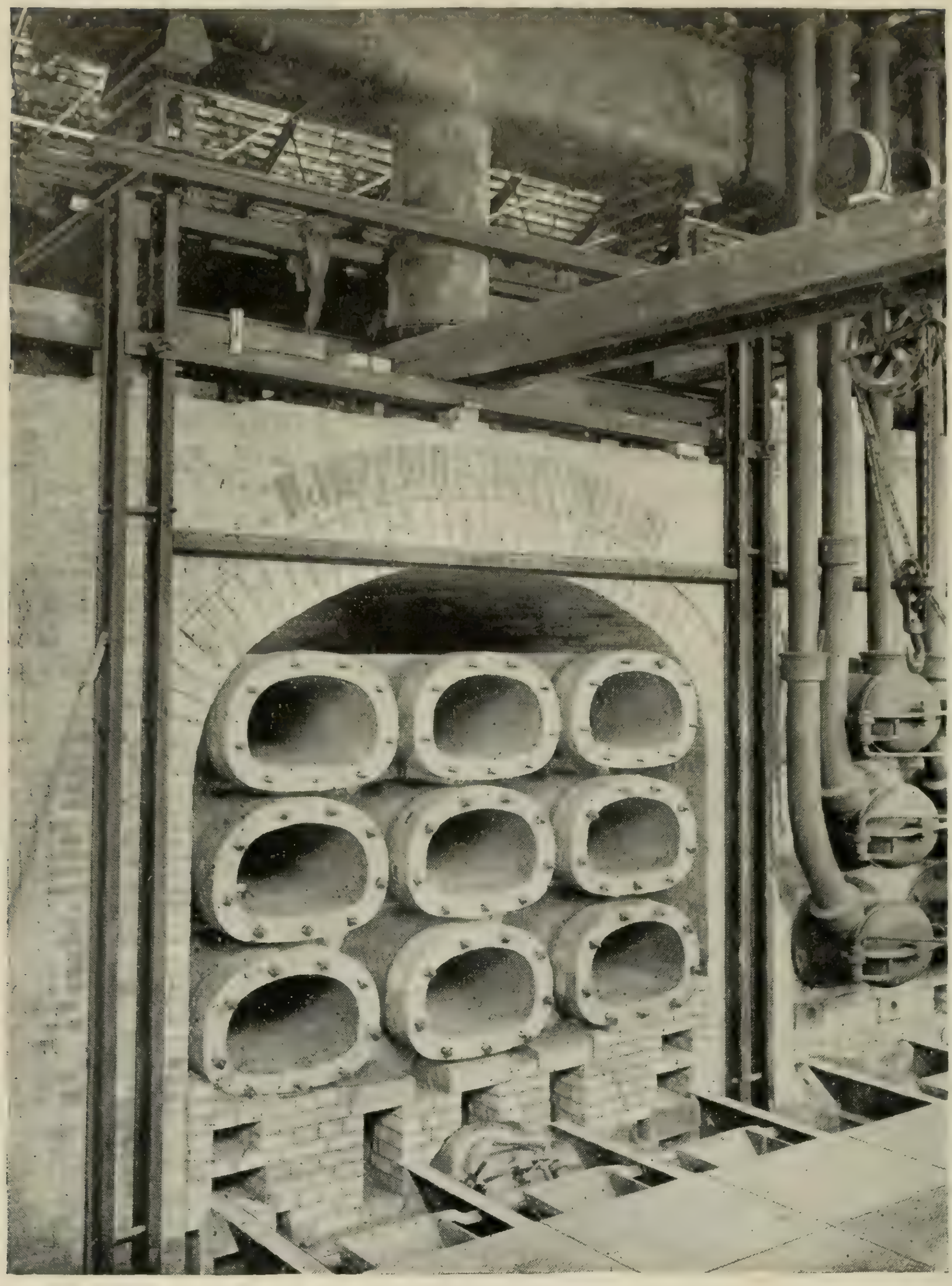
By C. J. R. Humphreys.

IN treating of the two general plans of gas-manufacture covered by the title of this paper, it is proper that we should first consider the coal-gas process, because it is the older; it is in fact the pioneer scheme of gas-making and is to-day the process most generally used. The science of gas-lighting grew out of the discovery made by Van Helmont, in the sixteenth century, that the dreaded " will o' the wisp " was merely an air or gas given off by decomposing vegetable matter. But the world profited nothing by this discovery until Clayton, investigating like phenomena some two centuries later, arrived at the same conclusion, and found, further, that a similar gas was given off by coal buried in the ground. Completing the chain by finding he could distill coal in a retort and produce gas, or inflammable air, as he termed it, the way was open for the discovery of gas-lighting. These facts coming to the attention of William Murdoch, of Cornwall, England, he was led to investigate the subject.

In 1792 he erected a small plant by which he lighted his house with this then strange air (or gas as we now call it), and this was at once the beginning of gas-lighting and the commencement of the coal-gas industry. In 1812 we find one Winsor, a German by birth but at that time residing in England, trying to start a gas company in London,—the nucleus of the present Gas Light and Coke Company, the first and largest gas company of the world,—and a year later we find Winsor lighting from his laboratory a portion of Pall Mall, this being the commencement of street-lighting by gas. The process used was the coal-gas plan, which has come down to the present day unchanged in principle, but greatly altered to meet the varied conditions of the business and the vastly greater demands made upon the sellers of gas, to produce the article in large quantities and at comparatively low costs. It would hardly be profitable to enter into a comprehensive description of



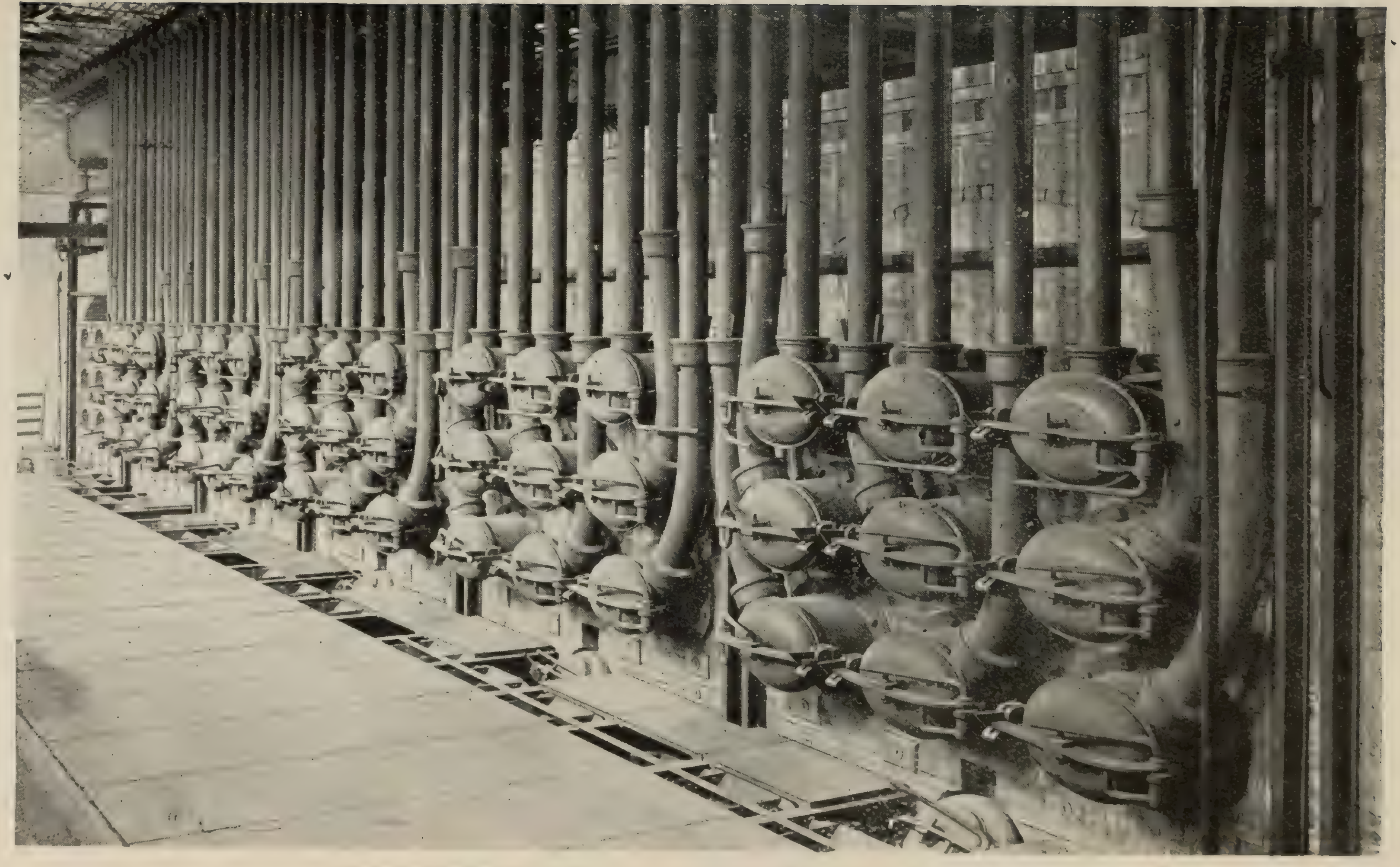
STYLE OF RETORT USED BY MURDOCH IN 1792.



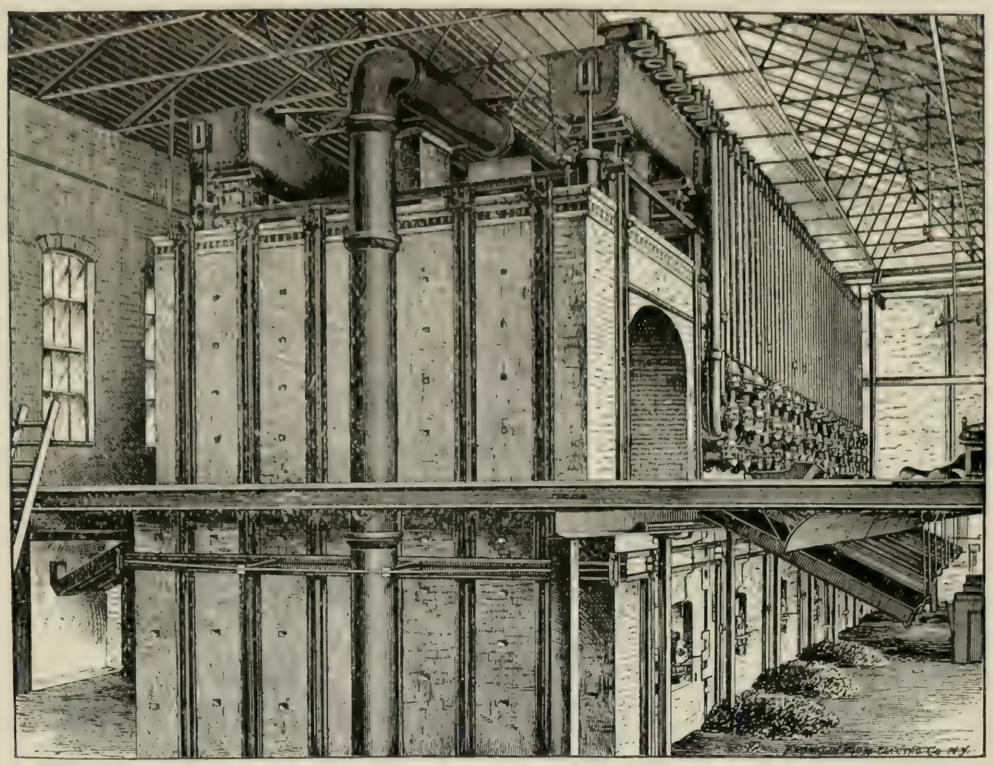
GAS-RETORTS UNDER PROCESS OF ERECTION.

the plant used at the beginning of this century, or to note the many changes which have been made in the apparatus since that time. Let us rather pass to a general description of the process.

Concisely, the fundamental principle of the coal-gas process is to distill bituminous coal—preferably of high grade, rich in volatile matter, and free from sulphur—in retorts highly heated and hermetically



VIEW OF MODERN GAS-RETORT HOUSE WITH FURNACES BELOW FLOOR.



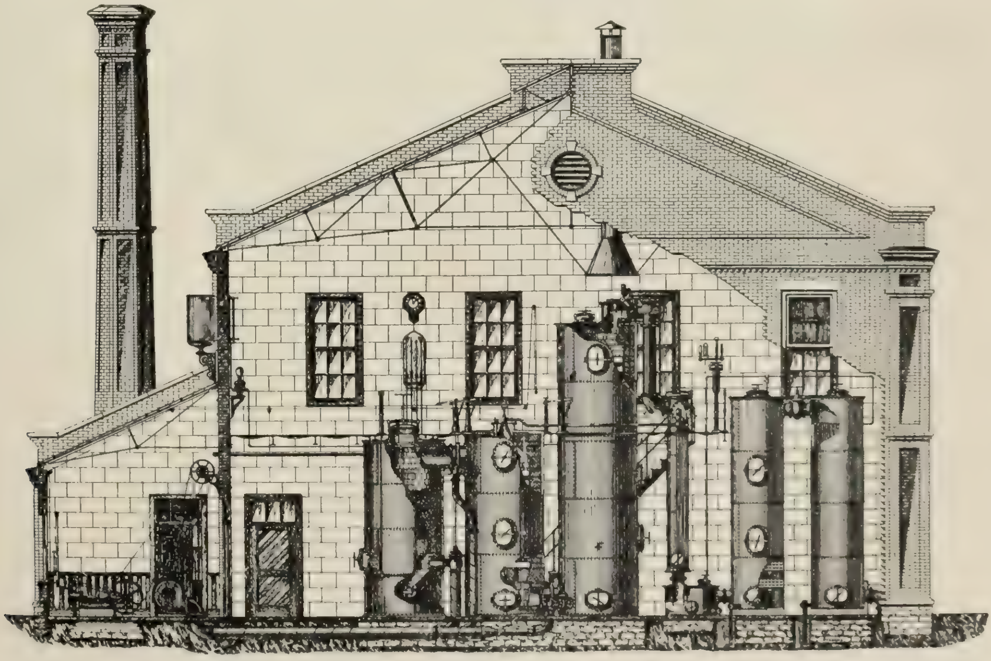
MODERN GAS-RETORT HOUSE—GENERATOR-FURNACES BELOW FLOOR.

sealed to prevent the coal from coming into contact with the air while undergoing distillation. The gas is led off from the retorts to the various apparatus, there to be treated for the removal of the different impurities and so be converted into a merchantable article. Much care is necessary in the selection of a coal for gas-making purposes. It must have a high percentage of volatile matter, which means that it must contain a large amount of gas; it must be comparatively free from sulphur; it should contain but little moisture; and the residual coke should be fairly hard and yet free from iron. The following analysis may be taken as fairly representative of the American gas coal:

Fixed Carbon.	Volatile Matter.	Ash.	Moisture.
62	34	3	1

The initial process of the manufacture takes place in the retort, which may be made of iron or fire-clay. As a matter of fact, the iron retort would not be suitable for the practical manufacture of gas as now carried on, for that material could not withstand the great heats to which they are nowadays subjected, but originally they were made entirely of iron. Indeed, as then manufactured, they might be considered as iron pipes, closed solidly at one end and having a lid to be applied at the other end, so secured as to prevent air from getting into the retort, or gas escaping therefrom. The retort now in use, while embodying the same idea, is made of fire-clay, the inside dimensions varying, though generally about 14 inches high and 26 inches wide and say 9 feet long. In shape they are very much like the letter D in this position : ⌓. The walls of the retort are generally about 3 inches in thickness, and it weighs about 1800 pounds.

A number of these retorts are built into a large oven, made of fire-brick, about 7½ feet wide and 8 feet high, and are heated by a fire below; the whole constituting what is technically called a "bench" of 3s, or 6s, or 9s, according to the number of retorts in the oven or arch. Attached to the ends of these retorts are cast-iron mouthpieces, so called, made to receive the lid and leading-off pipe for the gas. When such a bench has had a fire in it for about a week it is ready for gas-making. As the retorts are of fire-clay it is necessary to heat them up slowly; otherwise they would crack. It is hardly necessary to say there is no fire in the retorts themselves. The heat comes from the furnace in the lower part of the arch, this fire being maintained by the use of coke or coal, and the furnace-gases play all around the retorts before escaping up the chimney. When the retorts are ready for operation, the color of the retorts should have passed beyond red to orange, indicating a temperature of about 2000° F. The coal is put into the retort, or charged, as it is technically called, by means of two scoops made of iron, about 8 inches across the top and ∪-shaped and the door fastened on and made tight, generally by means



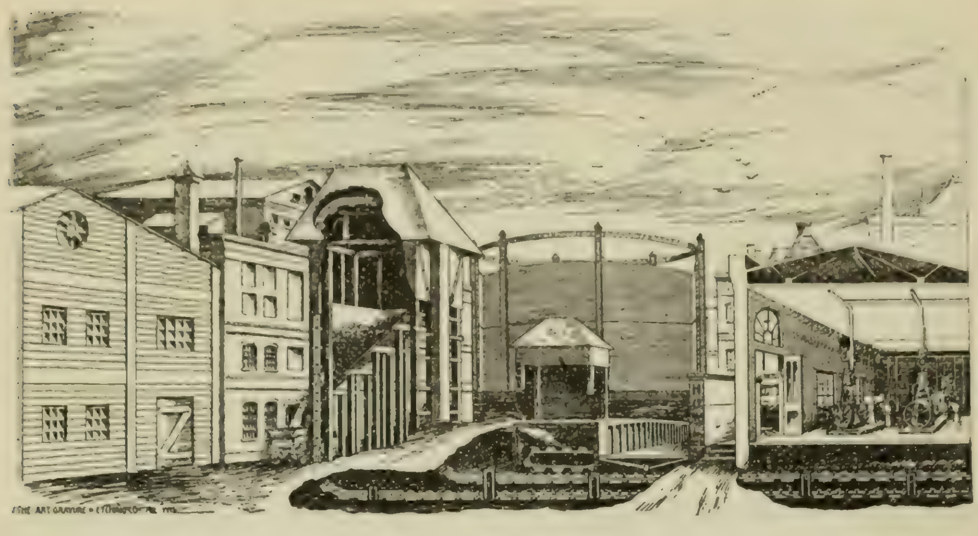
GENERATOR-HOUSE—DOUBLE SUPERHEATER SYSTEM.

VIEW OF OPERATING-FLOOR OF WATER-GAS GENERATOR-HOUSE—DOUBLE SUPERHEATER SYSTEM.

of luting, which is a sort of mortar, made from river-mud and lime. Now the process of distillation or carbonization commences. The heat from the furnace beneath causes the coal to break up, distilling off the gas and tar, the latter in the form of vapor. During the first two hours the process of gas-making goes on very rapidly; then it gradually slackens off until, at the end of four hours—the usual period of distillation under proper conditions—the coal has parted with all its gas and it is no longer coal, but coke; it is then drawn from the retorts by the aid of long iron rakes, and, falling into barrows, is wheeled away to be quenched; or a portion of it is drawn direct from the retorts into the furnace below, to continue the process of distillation, and the retorts re-charged with coal.

This fire is necessarily kept going night and day, Sundays and other days. These benches are built in various designs and sizes. Originally only one retort was set to a bench; that is, a fire heated only one retort, and now in small works they often put but three in a bench; however, in ordinary-sized works five or six is the more common number, and in very large works we find nine retorts over one fire. In the latter case the fire is generally run on the generator principle, which is a modification of the Siemens furnace. In the ordinary fire all the air necessary for combustion is delivered beneath the fire-grate and the fuel is thus burned at once to carbonic acid, but in a generator-furnace only half the requisite air is allowed to pass through the fuel, thus producing carbonic oxid; then a supplementary quantity of air, heated by passing through channels contiguous to the waste-gas flues, is delivered above the fuel, thus burning the carbonic oxid to carbonic acid, as in this case the combustion takes place well up among the retorts, and as the quantity of air to be admitted can be better graduated the results are much more economical and efficient. In an ordinary bench a retort will burn off about 250 pounds of coal in four hours, and, as the coal will produce about five feet of gas per pound, this means that a bench of six retorts will make about 45,000 feet of gas per day. A portion of the residuary coke is burnt in the furnace, this proportion varying from 25 to 40 per cent. of the coke produced. The retort-house of a manufacturing plant is made up by duplicating this bench as many times as may be necessary to meet the requirements of the city or town, and, in calculating the necessary number of benches, it is usual to allow a margin of about 25 per cent. over and above the requirements of the longest December nights, to permit of repairs. These retorts last from a year to a year and a half, when it is necessary to tear down the setting and refill the arch with new retorts.

As the gas passes away from the retorts up the take-off pipe, it has a temperature of about 150° F., and is largely charged with tarry vapors and contains many impurities, as ammonia, sulphuretted hydrogen, carbonic acid, and sulphur compounds, which must be eliminated before the gas can be distributed for general use. As the gas is not benefited by being kept in contact for a long time with the highly-heated retorts, and as the walls of the same are somewhat porous, a rotary pump or exhauster, as it is technically called, is used to draw the gas away from the retorts as rapidly as produced. Then the gas passes to the condensers, large iron machines wherein the gas is caused to pass through pipes surrounded by cold water, and as the gas is thus cooled the tarry vapors gradually condense into drops and fall away from the gas. This process is continued until the temperature of the gas is reduced to about 60° F., when the tar will have been practically disposed of. The gas then passes to a scrubber or washer, where it is brought into intimate contact with water. Sometimes these are built in the form of high towers, and are filled with wooden trays or grids. The gas enters at the bottom and water is distributed at the top; thus the ascending gas meets a continuous stream, or rather a large number of streams, of water. Then again they are built in smaller proportions and the gas and water are brought into contact by mechanical means; and, as a strong affinity exists between the water and ammonia, the latter gas is absorbed by the former and the gas passes along, freed from this impurity; the water flows off from the apparatus, as ammoniacal liquor, the source of aqua ammonia, sulphate of ammonia,

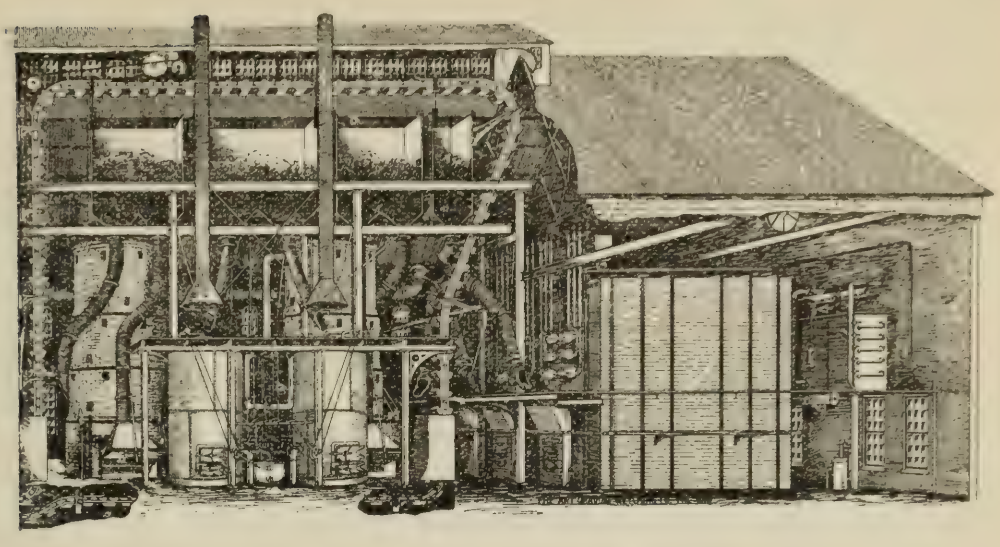


SECTION OF WATER-GAS PLANT.

etc. Then the gas is passed through lime, to remove the carbonic acid, after which it is brought into contact with oxid of iron—iron borings which have been oxidized—for the removal of the sulphuretted hydrogen and sulphur compounds. The vessels in which this process takes place are called purifiers, of which a gas-works has generally from four to six, the gas passing through all, save one, in succession. The purifiers contain trays or grids, made of slats upon which the purifying material is placed, and the gas, entering at the bottom of each of these boxes, rises up through the lime or iron and then passes off by the outlet-pipe to the next box, till it has traversed the series, when the operations of purification are supposed to be completed. The idle box, meanwhile, has been filled with fresh purifying material and made ready to be brought into action when one of the other boxes has become foul; that is, when the lime or iron has absorbed all the impurities it can hold. The gas then flows on to the station-meter, from which is taken the hourly record of the gas made. After this treatment we have, as the final product, an illuminating-gas of the following composition, stored in the gas-holders, ready to be sent out as required:

Illuminants	6.	per cent.
Light carburetted hydrogen	37.	"
Hydrogen	50.	"
Carbonic oxid	5.5	"
Oxygen, nitrogen, etc.	1.5	"
Total	100.	"

Let us now turn to the consideration of the water-gas process. To



(WILKINSON PROCESS)*

give merely a list of the various water-gas patents would absorb all our remaining space, and, moreover, would be found very dry reading; therefore, instead of attempting anything of this nature, we will take up only with those schemes which show the fundamental principles underlying the general water-gas process and which are more or less typical of the others. The scheme most used to-day is that known as the Lowe double superheater plan, the fundamental principle of which was patented by Professor T. S. C. Lowe, September 21, 1875. What might be called the first practical water-gas works were built by the inventor, in Phoenixville, Pennsylvania, in accordance with this patent, but, though in principle the same as the process now so extensively used, the general arrangements and mechanical details have undergone so many changes as to make the final product of scant resemblance to its original predecessor. But the principle is the same, namely, breaking up steam into its original elements by passing it through red-hot carbon and then giving this gas illuminating value by mixing therewith a rich oil-gas.

By reference to the plate on page 231 the general arrangement of the apparatus will be readily grasped. To the left is the generator,—a cylindrical vessel made of boiler iron or steel and lined with fire-bricks, of varying dimensions to suit the quantity of gas required, but generally about 6 feet in diameter and 13 feet high. Next to this comes the carburetter, of like construction and size, but filled by loose fire-bricks, laid in checker-work style; and then follows the superheater, which differs from the latter apparatus only in being about eight feet higher. Beyond the superheater are the washer and condenser, which are similar to such apparatus in the coal-gas works, though of smaller proportions.

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* Capacity 1,000,000 cubic feet per diem. Erected for Milwaukee Gas Light Company, Milwaukee, Wis., in 1890, by Bartlett, Hayward & Co., of Baltimore, Md.

In operating this plant the generator is filled with coal or coke, and, the fire being started, the whole mass of fuel is raised to bright incandescence by the aid of a blower which produces a forced draught or blast. After the apparatus is once heated the length of time the blast is kept on is usually ten minutes. It will be seen that the blast comes in at the bottom of the generator and is forced up through the mass of fuel, then passes by a fire-brick-lined pipe to the top of the carburetter and is forced down through the checker brick-work to the bottom, where it passes into the superheater, and, after traversing the brick-work in this apparatus escapes by the smoke-stack at the top. The blast-gases, in passing through the hot fuel, are raised in temperature, and subsequently impart this heat to the checker brick-work in the carburetter and superheater. It will also be noticed that each of the latter two apparatuses is supplied with a supplementary blast-pipe, and it is made use of in this way: if the valve which admits the forced draughts to the generator were opened to its full extent, practically all the fuel would be converted into carbonic acid, but if the full quota of air is not admitted at this point, the coal will be converted into carbonic oxid. When this gas passes over into the carburetter and superheater, and meets a further supply of air at these points, the carbonic oxid is burnt to carbonic acid, and in this way the checker brick-work therein is raised to the desired temperature. After these operations have been going on for ten minutes the air-blast is shut off, the valve on top of the superheater is closed, and steam is admitted beneath the fuel in the generator, and, this being in a state of active incandescence, the steam is broken up or dissociated by the red-hot carbon of the fuel and is resolved into its original elements, hydrogen and oxygen. The former passes along unchanged, but the oxygen unites with the carbon of the coal or coke and forms carbonic acid, and the latter, continuing in contact with the hot fuel, absorbs another quota of carbon therefrom and is changed into carbonic oxid. Hence, theoretically, the gas as it reaches the top of the generator is composed of equal volumes of hydrogen and carbonic oxid.

In practice, some carbonic acid will also be found present, but it is the object of the gas-maker to have as little of this gas as possible, as it is inert and detracts from, rather than adding to, the value of the flame. This gas is what is generally known as a crude water-gas; that is, it could give some heat but no light. To impart the lighting quality to the gas, oil is admitted under pressure at the top of the carburetter, either by small pipes or by an injector, and as the oil drops on the heated brick-work it meets the stream of hot gases—the hydrogen and carbonic oxid—coming over from the generator, and is thereby vaporized; the further passage through the hot carburetter and superheater converts the oil vapor into a fixed gas, and it passes down through the pipe to the water-seal or water-valve. In its passage it gives up some of its heat to the oil, and then continues along to the washer and condenser. The operations beyond this point are the same as in be the coal-gas process, so need not further described. When this gas-making process has gone on for ten minutes, the oil and steam are shut off, the valve on top of the superheater is again raised, and the operation of "blowing" up commences, so the process continues ten minutes for blowing up the apparatus and getting the checker-work hot, then ten minutes of gas-making. This process is typical of the class known as the internally-fired superheater, in that the heating is all done inside, and not from the outside, as in the coal-gas process. It will be noted the gas here made is a combination of a non-luminous or crude water-gas and an oil-gas. This is quite clearly shown by the following analysis of the gas as distributed from the works:

Illuminants	14.	per cent.
Light carburetted hydrogen	20.	"
Hydrogen	37.	"
Carbonic oxid	25.	"
Oxygen, nitrogen, etc	4.	"
Total	100.	"

In reference to the differences in the two processes it is well to note that the apparatus here shown takes the place merely of the retorts in the coal-gas scheme. The apparatus shown is the foundation scheme of all the cupola superheater plans.

We may take the Wilkinson process as representative of another type of water-gas apparatus. In this case the initial process is the same,—that is to say, a crude water-gas, composed of hydrogen and carbonic oxid, is produced in a generator which is usually made about 8 feet in diameter and 15 feet high. As in the generator previously described, there is an opening on top for the admission of coal and air-tight doors at the bottom for clinkering. In the running of the apparatus the blast is put on for ten minutes, after which, the fuel having been raised to incandescence, the steam is admitted at the bottom and the process goes on as already described. At the end of five minutes the steam is shut off from the bottom of the generator and is admitted at the top; the gas for the remainder of the time is taken off from the bottom of the generator. At the end of the ten minutes the blast is again put on, and so the operations are repeated. From here the gas—still the crude, non-luminous water-gas—passes through the condenser and then to a small holder; from there, the gas is brought back by an exhauster or rotary pump to the "illuminator"; the object of this machine is to impart luminosity to the gas by causing it to take up the vapors of naphtha. The illuminator of common size, capable of taking care of 500,000 feet of gas a day, is 3 × 10 × 10 feet, and is divided by inclined horizontal shelves on which steam-coils rest.

Naphtha is admitted at the top of the machine and flows from shelf to shelf. The heat from the steam-coil vaporizes the naphtha and this vapor is taken up by the entering crude water-gas. From the illuminator, the mixed naphtha vapor and water-gas pass to clay retorts similar to those already described, in connection with the coal-gas process, and, these being highly heated, the naphtha vapor is converted into a fixed gas. After this, the gas passes through condensers and purifiers and is then ready for distribution.

By either of these processes a high-candle-power gas can be made, and herein lies one advantage water-gas possesses over coal-gas,—namely, its increased brilliancy. Coal-gas generally runs from 17 to 19 candles; that is, five feet of gas would, during an hour, give the light equivalent of 17 to 19 standard candles, whereas water-gas will run from 20 to 30 candles or even higher. Another advantage, from the manufacturers' standpoint, is the increased quantity of gas which may be made per unit of floor-area, which, with water-gas, is about four times more than with coal-gas.

A misconception exists on the part of some in regard to the heating-power of the crude water-gas,—that is, before the admixture of the oil-gas,—and, working on these wrong ideas, attempts have been made to distribute this non-luminous gas solely for heating purposes, but they have not been successful for the reason that the hydrocarbons which come from the oil impart not only light, but heat as well. Thus the luminous water-gas will have a heating power about the same as coal-gas, namely, 650 to 750 heat-units per cubic foot, whereas the crude water-gas will have only about 290 heat-units. It will thus be seen that even for the purpose of obtaining heat a crude and non-luminous water-gas would have to sell at 60 cents to give the same amount of heat as could be obtained from the luminous gas at $1.40.

It is often asked what is the relative cost of coal-gas and water-gas, and a vast amount of misinformation has been published on this point. Exploiters of apparatus have dwelt on the fact that the gas is made from water, and, since water is cheap, the cost of the process is slight. This is certainly playing with words. It is true that the hydrogen and part of the carbonic oxid come from the water or steam, but it is also true that a great deal of energy is required to wrest these elements apart when existing in the form of steam or water, and energy costs money. In the coal-gas process energy is required to force the coal into its elementary constituents. In like manner energy is called for in the water-gas process, and whether one scheme or the other is the cheaper will depend upon the locality. It is impossible to lay down any rules for general guidance on this point. The factors are the cost of bituminous coal, anthracite, oil, and the figures a company can obtain for the residuals from the coal-gas process,—coke, tar, and ammonia. The quantity of gas to be obtained from a ton of coal is much more with water-gas than coal-gas—in the one case 45,000 feet against 11,000—but in the former instance 200 gallons of oil would need to be used with the ton of coal.

There was a time when great competition existed between the advocates of the coal-gas process and the water-gas process, and many violent statements were made on either side respecting the value of one scheme and the evils of the other. We were told that coal-gas was a relic of by-gone days,—a scheme suited to the early days of the century, but not up with the push and enterprise of its closing years,—and that the water-gas, being more free from sulphur than coal-gas, and requiring less air for its combustion per unit of light than coal-gas, was more suitable for domestic use.

On the other hand, we heard the assertion that water-gas was not a homogeneous gas, that it varied in candle-power, that it contained tarry vapors, and was more harmful when escaping unconsumed. Now that the smoke has cleared away, we can see more plainly the advantages of each system; we can see that a process is not necessarily obsolete because it was used by our fathers; we can see that, by the improved apparatus now in use, water-gas can be made as stable, as uniform in candle-power, and as free from tar as by any other scheme, and that, all things considered, one gas is as well adapted to domestic use as the other.

As the question is studied more and more, we find that the proposition changes, and, instead of reading water-gas *versus* coal-gas, we read water-gas *and* coal-gas, for we find the modern gas-works does not confine itself to one process, but, by adopting both and utilizing the advantages offered by each, produces a gas which has no equal the world over.

THE STORAGE BATTERY AND ITS USES.

By Townsend Wolcott.

THE storage battery has become an important factor in the field of industrial electricity, and the popular interest therein is steadily growing. It is frequently asked, what is a storage battery and wherein does it differ from an ordinary battery? The several current names for the same thing—storage battery, accumulator, and secondary battery—have been severally objected to by different critics as being inaccurate. The name storage battery is designed to describe the apparent fact that electricity may be stored in the cells and drawn out again at pleasure. The name accumulator is nearly equivalent, and points to the same fact or supposed fact.

These names are not strictly accurate, since electricity is not really stored but simply passes through the battery, causing a chemical change therein which, when it is reversed, is capable of furnishing another current in the reverse direction. That is, the chemical condition of the cell during the discharge tends to reverse or undo what was done during the charge. The use of these names is justifiable, however, on the same ground as that on which we justify the use of the word sunrise.

The name secondary battery indicates the fact that the battery is not active when first made, but only after it has been acted upon by some primary source of electricity. But as it is possible—though perhaps not practicable—to make the battery at once active, a better name would be reversible or recuperative battery, as it can be repeatedly exhausted and revived. This latter property constitutes the chief difference between storage batteries and ordinary voltaic batteries, or primary batteries, as they are sometimes called. Another difference, entirely unconnected with the regenerative principle except by mere coincidence, is the fact that several regenerative cells have been already produced which possess a power of delivering current out of all comparison with any primary cell yet invented. The great power of storage batteries gives them an importance, from an engineering and industrial standpoint, far greater than that of any primary battery.

Important as it now is, the storage battery may be traced to a very obscure orgin. In 1801 Gautherot, a French scientist, while using a voltaic battery with silver-wire electrodes to decompose saline water, noticed that, upon disconnecting the battery, the vessel containing the saline solution and the silver electrodes was capable of furnishing a current of short duration in the direction opposite to the original current. In 1803 Ritter observed a similar action with gold wire, and constructed a battery out of pieces of gold separated by disks of cloth moistened with a saline solution. This resembled the pile of Volta, except that the plates were of one metal.

It is worthy of note that this first storage battery should have been made so early in the history of the voltaic cell, for there was a well-directed attempt to practically utilize the reverse current phenomenon, which received the name of polarization. Years after this polarization was a great source of annoyance in primary batteries. After a primary battery had been in operation for a time a marked falling-off in the electromotive force (or intensity, as it was then called) was observed. This was found to be due to the collection of hydrogen gas on the unattacked electrode, and in 1836 Daniell invented the well-known sulphate-of-copper battery, which evolves no hydrogen but deposits copper on the copper electrode.* As there is no change in the surface of the electrode there is no polarization, and this was the first depolarized battery. Polarization was also an evil to be overcome in the solutions used for the electrodeposition of metals.

From the times of Gautherot and Ritter to 1860 there were some discoveries in the direction of the modern storage battery, but in the last-mentioned year Gaston Planté brought out a cell which was the beginning of the practical storage battery. This cell consisted of two sheets of lead, separated by a cloth and rolled into a cylindrical form. The roll was placed on end in a jar of dilute sulphuric acid, and charged, first in one direction and then in the other, with intermediate discharges. After this treatment had been repeated a great many times the chemical action penetrated deeply into the plates and increased the storage capacity in a corresponding degree.

This "forming" process, as it was called, was tedious and expensive, and to obviate the necessity for it Camille A. Faure, in 1881, used a layer of lead oxids spread over the surface of the plates. This layer of oxid was converted by the action of the current on one plate into peroxid of lead, and on the other into metallic lead in a spongy or porous condition. The active material, as these layers were called from the fact that they constituted the portion of the cell which furnished the current, had to be held in place by felt diaphragms or partitions. It will be observed that this construction differs from that of Planté only in starting with ready-formed oxid of lead.

One of these cells was sent from Paris to Glasgow and was examined by Sir William Thomson, who considered it a wonderful advance in battery-construction and stated that it contained 1,000,000 foot-pounds of energy.

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* This is the usual statement, but, according to Tommasi, the principle was discovered by Becquerel, in 1829, and Wach in 1830. It does not appear, however, that either of these investigators appreciated the full value of the combination as a depolarized cell as did Daniell.

T. W.

This certainly was a large amount of energy for one cell of storage battery to contain, especially at that time, but as compared with the energy stored in coal it is small,—not greater than the amount of energy utilized from one pound of coal by a good steam-engine. The interest in the storage battery excited by Sir William Thomson's favorable report gave it an impetus so great that its practical use may be said to date from that time.

The next improvement was to use a perforated plate (or "grid"), which appears to have been invented by G. Philippart, though it was patented in France by E. Volkmar. Philippart filled the perforations in his plate with finely-divided metallic lead, but the results were not so satisfactory as those afterward obtained by using Faure's oxid paste to fill the grids. Sellon used an alloy of lead and antimony for the grids, instead of pure lead. These combined inventions have since been known as the Faure-Sellon-Volkmar system.

There are now in use two types of storage battery which far outnumber all others. One consists of grids filled with Faure's paste, and the other of modified Planté plates. The merit of the grid is that it holds the oxid so that felt or other diaphraghms are unnecessary. In the improved Planté cells the diaphragms are likewise dispensed with. The storage battery thus improved is much simpler than any good primary battery. There is a series of flat plates alternately positive and negative, the number of negatives being one greater than the number of positives, so that the series begins and ends with a negative. These plates are insoluble in the acid, and not visibly altered by charging and discharging the cell. The liquid is dilute sulphuric acid alone, while most primary batteries that are at all powerful have two liquids separated by a porous jar.

The insolubility of the plates and the absence of partitions permit of close packing of the plates, and a consequent improvement of the cell in two respects: (1) economy of room and (2) decrease of internal resistance, both from the diminished distance and increased plate-surface, the resistance of a good cell of moderate dimensions being only a few thousandths of an ohm. This low internal resistance brings the storage battery into some sort of reasonable comparison with dynamos of the same output, a position which primary batteries have never approached.

The chemistry of these lead-lead-peroxid cells is, roughly stated, as follows: Upon discharge the peroxid plate loses oxygen, and the spongy lead plate gains oxygen in equal amount. The protoxid (litharge) formed by the partial oxidation of one plate and partial de-oxidation of the other plate is converted into sulphate of lead, at least partially. Upon recharge these reactions are reversed. These are the reactions which are available for the storage of energy. There are other reactions, such as the throwing off of bubbles of hydrogen gas upon charging which simply represent waste electrolysis.

The fact that nothing passes from plate to plate but oxygen, and no solid is dissolved and redeposited, is a great advantage, to which may be added the advantage of a comparatively constant composition of the electrolyte. The acid is simply weakened upon discharge, owing to the formation of the sulphate of lead, and restored upon recharge owing to the decomposition of the sulphate.

The spongy lead plates may be replaced by plates of metallic zinc, with the result of a marked increase of electromotive force; an increase from an average of about two volts to about $2\frac{4}{10}$ volts, according to the state of charge. But the solid zinc has to be dissolved and redeposited, which for a long time caused a great deal of trouble owing to the fact that it redeposits in warty, irregular masses. This difficulty has been partially obviated, but in any event the plates have to be set farther apart. The electrolyte also passes through a much greater change. In the fully-charged cell the electrolyte is sulphuric acid; in the fully-discharged cell it is sulphate of zinc with no free acid, as it is necessary to have an excess of zinc in order to prevent the complete destruction of the electrode.

The combination of peroxid of lead and zinc for a primary battery is very old. Wheatstone used it in 1843, and several others soon after. The first serious attempt to use it as a storage battery seems to be due to d'Arsonval and Carpentier, who took out a patent therefor in France in 1879. This type of battery has probably reached its highest development in this country through the labors of William Main.

There is another type of storage battery of commercial importance, known as the alkaline accumulator. The names connected with its introduction in France are Lalande, Chaperon, Commelin, Desmasures, and Bailbache, and in this country Waddell and Entz. The battery consists of zinc and copper electrodes, in caustic alkali. The zinc is dissolved and redeposited, and the copper oxidized and deoxidized. The chief merit of this battery is in its light weight in proportion to its output. The current output per pound weight is very large, but the electromotive force is only $\frac{7}{10}$ or $\frac{8}{10}$ of a volt, so that the power output is much less in proportion, as compared with lead batteries.

When Planté's experiments were new, and again on a larger scale when Faure's "marvelous box of electricity" was announced to the public, the hopes of electricians and others interested in the matter were raised to a high pitch in regard to the possible uses to which storage batteries might be put. These hopes have not by any means been realized, and in some quarters the storage battery is regarded as being in large measure a failure, and even where it is not so regarded it is generally blamed for all unfulfilled promises.

Than this nothing could be more unfair, for two reasons. First, in the United States at least, the storage-battery business has been largely in the hands of speculators with insufficient capital, no technical knowledge, and no desire to employ technical talent, the sale of stock being considered as an ultimate end. Second, as the storage battery is only one element in a complete plant for generating and storing energy, the battery should not be blamed, as it frequently has been, for the fault of the rest of the apparatus. For instance, the largest schemes proposed, in which a part was to be played by storage batteries, were for the utilization of wind- and tide-power. As to the wind-power question, specifications have been published of windmill-battery plants which would cost more than $1000 per horse-power, estimated on the normal full-load capacity of the windmill. In most localities this cost would be much increased, if estimated on the average steady horse-power which could be delivered for ten hours daily, on account of the uncertainty of the wind. But even if this first cost were not too high, or if the windmill cost no more per horse-power to install than a steam-plant, the conditions under which the battery would have to work would be most unfavorable.

The most favorable condition for the operation of storage batteries is regularity of charge and discharge, and especial attention should be paid to recharging soon after discharge, as the batteries deteriorate rapidly if allowed to remain long discharged. On the other hand, they may remain for considerable periods when fully charged, without harm. The very nature of wind-power would leave a large chance of the battery being caught in a calm in a discharged condition, unless there was an enormous storage capacity in proportion to the daily consumption, which would again raise the question of prohibitory first cost.

An intermittent power, with a regular or approximately regular period which can be absolutely depended upon, furnishes the most favorable condition for the utilization of storage batteries. Such a power is contained in the tides, but no one has yet extracted it. That is to say, the tide-motor which will furnish a really cheap power has not yet been produced. There seems to be no genuine advance on the ancient method of damming up water at high-tide and using it as the tide falls. Such tide-power is not always cheaper than steam-power, and, in these days of improved steam-engines, engineers are becoming more and more conscious of the fact that it takes a very good water-power to furnish energy more cheaply than a steam-plant on a large scale. Given a really cheap power from the tides, the storage battery undoubtedly could handle the regulating part, which is all that it should be expected to do.

But there are cases where the storage battery has already proved a success, technically, and commercially. In central stations devoted chiefly to lighting, the load is of course nearly all during the dark hours, as day-lighting, except in large cities, is little or nothing. The usual practice is to sell power as well as lights and so to run the plant through the twenty-four hours, as the call for power is chiefly during daylight hours. Nevertheless, there is a considerable fluctuation in the load-diagram in most stations, and a consequent opportunity for the advantageous use of storage batteries.

Where a station runs only a portion of the twenty-four hours, for lighting alone, there is generally a maximum load some time after dark and before midnight. It is usual for some lights to be turned off at 10 P. M., others at midnight, etc., while some burn all night. In many small stations there are only a few all-night lights, and the station has to be kept running for these few, whereas they might be easily run from storage batteries which could be charged at such times as the load permitted while the dynamos were running. As the load decreases late in the night the surplus energy of the dynamos may be turned into the batteries until they are fully charged and the remaining night's work within their capacity. Then the power may be stopped until the next evening, and the batteries partially charged while the load is light.

Where a station runs during all of the twenty-four hours the batteries may be charged during the hours of light load, and discharged so as to assist the dynamos during the intervals of over load. Of course any plant will earn a larger dividend on the investment working all the time than when only working a portion of the time, provided the average load is high enough in proportion to the extra operating expenses, but even then it pays to keep the load at times as near the average as possible. In stations which do not run all the twenty-four hours, it will frequently be found that the average load is enough below the load at which the apparatus gives its best efficiency to allow of considerable saving by shortening the hours and reducing the operating expenses as outlined in the foregoing case.

The modern steam-engine, as constructed for driving dynamo-machinery, is a very admirable machine, and gives, under reasonable fluctuations of load, a high efficiency, and, under violent fluctuations of load, a very close regulation of speed. It is too much to ask, however, that an engine should also give a good efficiency under these violent fluctuations, as the regulation is accomplished by admitting varying amounts of steam to the cylinder at each stroke, and high efficiency can only be obtained by using steam very expansively.

It has been proposed therefore, to supplement the engines and dynamos of trolley roads with storage batteries to be used after the manner of fly-wheels. In this service they could undoubtedly be made useful, but the larger the road the more load averages up, which would seem to indicate that the larger loads would have no use for batteries; still an examination of the load-diagrams of many fairly large roads shows that there is room left for improvement in the way of evening up.

One of the chief hopes of storage-battery men was street-railway traction,—of all uses to which it could be put the most trying. So far it has not been a marked success, though in the easier service of European cities it has been to some extent successful. The most characteristic feature of street-car propulsion, especially under the usual conditions in America, is the enormous power required, especially in starting, in proportion to the seating capacity of the cars, it being in some cases many times greater than for steam-railways. It is the ability of the electric motor when supplied from a trolley-line to supply this extraordinary demand for power which has made the trolley principle such a wonderful success in so short a time, and in many cases where steam locomotives would have failed to furnish sufficient propelling power had they been allowed to make the trial.

It is not reasonable to expect that we can charge a storage battery from a dynamo and then drive a motor from it without a loss in conversion greater than the line loss in the case of a trolley system, except under extraordinary circumstances. The more conservative battery-men, therefore, have never expected to rival the trolley on the ground of efficiency, but have confined their field of usefulness rather to special cases,—for instance, where the trolley was objected to, as in the larger cities, and where, as in some suburban traffic, the cars had to travel a long way from the power-house, involving a large line loss and a large outlay for line construction where the traffic was small.

But as the early experiments in storage traction in cities were very unsatisfactory, and as the public grow weary of waiting, the trolley was introduced into city after city, until they are nearly all supplied, and the chances for the storage battery in that line have grown beautifully less. It is usually stated that the storage battery is too heavy for traction purposes, but it is safe to say that weight is not the principal cause of failure thus far. Of course a reduction in weight would be desirable, but there have been trolley cars of the gearless-motor type which weighed more than a battery car complete, having a different type of motor. The principal cause of failure has been the rapid deterioration of the cells in this class of work where the demand for current fluctuates frequently and rapidly, between nothing and the utmost capacity of the battery. It is a question of bookkeeping pure and simple, of how much can be paid in any given case for the renewal of cells without eating up the profits. As the manufacture of batteries is improving and their ability to stand hard usage is increasing, the cause of storage-battery traction is looking up.

In another branch of propulsion, where the demand for power is more moderate, the storage battery is a pronounced success. This is the propulsion of small boats, or electric launches, as they are called. In fact, one of the earliest practical applications of the storage battery was for this purpose.

There are numerous uses for storage batteries on a small scale. Any portable apparatus in which primary batteries are commonly used may be operated by storage batteries to advantage if the proper facilities for recharging are at hand. For the electric-lighting of railway trains they have given perfect satisfaction, and on a smaller scale they have been used for coach-lights. Thus it will be seen that while the storage battery has not yet succeeded to its estate, it has a wide and promising future, where in its legitimate applications it is likely to make manifest its virtues which, if wisely directed and properly applied, will make it one of the most useful accessories to modern dynamo electrical machinery.

MEASUREMENT OF THE ELECTRIC CURRENT.

By Nelson W. Perry, E. M.

WHAT, measure an invisible, intangible, imponderable something whose exact nature we confess we do not yet understand? Yes, and measure it more exactly and more easily than we can coal or heat or light. Though it is invisible we may measure it by its appearance; though intangible we may measure it by its touch; though imponderable we may measure it by its weight. We may measure it in quarts, yards, pounds, candle-power, in horse-power, by the thermometer, by cubic feet, and, in fact, in almost any way in which visible, tangible, ponderable entities are measured.

This seems to be a most anomalous statement, but it is nevertheless true. It will be made more clear, however, when it is stated that the methods of measurement are in accordance with the scriptural rule: "By their works ye shall know them." It is not electricity itself that we measure in the units above mentioned, but the results which are produced by this mysterious something when allowed or caused to act in various ways. For instance, it is an axiom that like causes produce similar results. It follows that if we multiply these causes the results will bear some definite relation to the multiplied cause, and, if we can discover what this definite relation is, the first result may be taken as a unit by which to measure the second result. Sometimes this relation between multiple causes and their effects is quite simple while at other time complex, but they have now been so carefully studied that they are pretty well understood. Thus of the simple relations, we now know definitely that the amount of gas liberated in the decomposition of water by the electric current (electrolysis) is directly proportional to the current. Therefore, if one current liberates twice as much gas in a given time as another, we know that the former was twice as large as the latter. In this case, if the smaller current liberated one cubic inch of gas, one might with propriety say that one cubic inch of electricity had passed in the latter and two cubic inches in the former. The amount of a given metal, too, which is deposited from solutions in given periods of time is directly proportioned to those currents, and if this be weighed, current might be considered as measured in pounds and ounces.

As an illustration of the more complex relations between cause and effect, may be mentioned the production of heat in a conductor by a current passing through it. Double the temperature no longer indicates that twice the current is passing, however, for it takes very much less than double the current to produce double the heat. It has been found that the heating effects of electricity are proportional to the *square* of the currents passing, viz.: that two units of current will produce four times as much heat as one unit, and three units nine times as much. Where electricity is employed to produce light, the relations are still more complex, the illumination varying about as the fifth power of the current. If these relations are perfectly definite we can measure the current in the former instance by degrees of temperature, and in the latter by candle-power.

Of two clocks which normally run synchronously, if one be retarded or accelerated by the passage of a current through a neighboring electro-magnet or otherwise, if we introduce a planetary movement into the clock mechanism, it may be made to revolve a spool or drum upon which will be wound or unwound a tape or string, and when we wish to know how much current we have consumed we may measure it off in yards or inches, or more directly from the clock-dials, in hours and minutes, which are the measure of the retardation or acceleration of one clock over the other.

Thus we may use any of the effects of the electric current which lend themselves readily to measurement as substitutes for their causes and express the values of the currents in any of the units by which the effects themselves are usually measured. In this way we have the choice of an almost infinite variety of metering methods depending upon the well-known properties of electricity.

Among the properties of electricity most usually relied upon to enable us to measure it are—

1. Its property of producing magnetism.
2. Its property of causing a freely-suspended magnet to take up a position at a greater or less angle to the direction of the current.
3. The property of the mutual attraction and repulsion of currents.
4. The suction of a solenoid traversed by a electric current upon a magnetic core.
5. The elongation of a wire due to the heat caused by the passage of current.
6. The electrolytic decomposition of liquids or solutions.

The method of determining results by indirect methods so generally employed in electrical measurements is not necessarily a source of inaccuracy or uncertainty, nor is it unique in exact science. In chemistry, for instance, it is the exception rather than the rule that an element or base is determined directly. The constituent sought is usually precipitated and weighed as a salt of known composition, and, from the weight of this salt, the weight of the element to be determined is obtained by calculation.

Current can be measured either absolutely or relatively. The absolute determinations are exceedingly difficult, requiring the most painstaking care, often extending over months of time. As an illustration of the difficulties of absolute determination it may be mentioned that the committee of the British Association appointed to redetermine the value of the absolute unit of resistance made an error of 1½ per cent., so that the old unit was only equal to .9866 of the new unit. It is a method that should be relegated to the scientist, or rather to a committee of scientists, thoroughly skilled in such work, and has no interest either to the engineer or the lay public. On the other hand, the relative determination is so easy that a lecturer on this subject, Professor Francis B. Crocker, once said he thought that a telegraph-boy, after a short period of instruction, could make a measurement with an error not to exceed one-tenth of 1 per cent., and that a student might do somewhat better after a month's instruction. It is the relative determinations, therefore, with which this paper will deal. The six different properties of the electric current mentioned above, upon which we depend for these determinations, all involve either one or the other of four fundamental principles, viz.: electro-magnetic, electro-dynamic, electro-chemical, and electro-thermal. Upon these four principles depend all the various forms of measuring-instruments.

Of the electro-magnetic instruments, perhaps the best example and the simplest is what was known as the Bergman or Edison amperemeter, which consists of a coil of wire which, when traversed by a current, draws an iron armature within itself as the current increases, and by this motion causes a needle to pass over a dial that has been calibrated from some reliable instrument.

It must be borne in mind that, as in every-day life we have need of hay-scales as well as chemical balances, so we have use for electrical instruments which give but approximate results as well as those of the utmost delicacy. Instruments of the kind just mentioned are the hay-scales of electrical instruments, but they find great use in central stations and electric street-railway power-houses where current is turned out at wholesale and approximations to the amounts only are desired.

One of the great faults of instruments of this kind and one which prohibits their use for more accurate determinations, is that the readings of an increasing current differ from those of a decreasing current. This is due to the iron core which introduces what Professor Ewing calls *hysteresis*, which is the lagging of a magnetic effect behind its cause. That is to say, if the current should suddenly increase, owing to the magnetic sluggishness of the iron core, the instrument would not register quite as high as it should, and, if the current should then suddenly decrease to its former quantity, for the same reason the instrument would not read as low as it should ; its reading on an increasing current would be lower than its reading for the same current that was decreasing from a higher value.

The instruments constructed on the electro-dynamic principle, of which the Siemens electro-dynamometer and the Thomson balance are examples, and which depend for their action upon the mutual attraction and repulsion of currents, do not have this defect, since they contain no iron in their construction.

A difficulty presents itself with instruments of this class also. Owing to the fact that the mutual reactions of currents are not proportional to the currents themselves, but to the squares of the currents, the graduations on the dial-plates are not equal for equal increments, but increase very rapidly from very small to very large divisions. They possess, however, the very important advantage, which some classes of instruments do not possess, of being equally applicable to the measurement of both direct and alternating currents.

Under the head of electro-chemical meters come those which depend upon the power of an electric current to decompose liquids and solutions of metallic salts. As they liberate gases by this process, or deposit metals, they are called gas or metallic voltameters. If the former, the gas is usually measured, if the latter, the metal is weighed. The gas voltameters have very little practical interest but the metal voltameters have come into very extensive use. The best-known meter of this class is the Edison meter, which consists of two amalgamated zinc electrodes immersed in a solution of sulphate of zinc. The action of the current is to cause a transfer of metal from one electrode to the other. Since the amount of metal deposited on the one or dissolved from the other is exactly proportional to the current, the gain in weight in the one or the loss in the other is an exact equivalent of the current passing. In order that the whole of the energy of the current shall not be consumed in the operation of measuring it, as would be the case were it all passed through the voltameter, the latter is placed in a shunt circuit whose resistance is so proportioned that it will take off but $\frac{1}{975}$ part of the current. As a means of check, two voltameters are always placed in each circuit in parallel, and since the Edison current is usually distributed by the three-wire system which extends into every customer's house, and which really constitutes two circuits, the Edison meter as installed consists of four voltameters—two for each circuit. In reading the meters for the determination of the bills, a losing zinc of one bottle and a gaining zinc of the other, of each pair, are weighed, the one as a check on the other. Since a change of temperature affects the conductivity of metals and liquids in exactly opposite ways, though in different degrees, a neat method of compensating for temperature is resorted to. This consists in introducing into each bottle-circuit a coil of copper wire of such length that the loss of conductivity of the metallic portion of the circuit by increase of temperature will just balance the gain in conductivity in the liquid portion due to the same cause.

While this meter is capable of giving quite accurate results under favorable conditions, the conditions of commercial use are not such as to make it really an instrument of precision, but it is accurate enough under these conditions for all practical purposes, the range of error rarely exceeding 2 per cent. As indicating into what general use this meter has come, it may be stated that in New York city alone 200,446 16-candle-power incandescent lamps, 2680 arc lamps, and $6117\frac{92}{100}$ horse-power of motors are supplied from 5500 Edison meters. It may be interesting in this connection to show how the bills are made out from this meter after the zincs have been weighed.

One ampere-hour of current will deposit 1.224 grams of metallic zinc. But since only $\frac{1}{975}$ part of the whole current used passes through the voltameter, the amount of deposit which will represent an ampere-hour of current will be $\frac{1.224}{975}$. The Edison Company sells current in lamp-hours, viz.: using the amount of current consumed in one hour by a 16-candle-power lamp as its unit, and charges for this 1 cent. A 16-candle-power lamp requires .424 of an ampere of current, therefore the weight of zinc deposited per 16-candle-power lamp-hour will be $\frac{1224}{975} \times \frac{424}{1000}$ and there will be as many lamp-hours for every gram of zinc deposited as the result of the multiplication of these fractions is contained into 1. This may be expressed thus:

$$\frac{1}{\frac{1224}{975} \times \frac{424}{1000}} = \text{number of lamp-hours per gram of zinc deposited,}$$

and this at 1 cent per lamp-hour equals \$18.75. This is what is known as the "lamp constant." By multiplying this by the number of grams and fractions of a gram deposited, the customer's bill is determined at once. It is evident that this meter cannot be used on alternating-current circuits.

The thermo-electric methods are not much employed for measuring currents but when used at all are employed to determine the voltage. The Cardew volt-meter is the most familiar instrument built on this principle, and consists simply of a long wire through which the current passes and which by its expansion and contraction due to the changes in the strength of the current actuates an index-needle.

It is usually stated that this meter is equally applicable to either alternating or direct currents but this is not strictly true. It may, indeed, be used for either current if properly calibrated for the current upon which it is used, but an instrument calibrated for direct currents will not give correct readings if placed on an alternating-current circuit, and *vice versa*, as the heating effects of the two are not alike.

While there can be nothing simpler than the Cardew instrument, it is open to the serious objection that it consumes an enormous amount of current, relatively speaking. While on this subject of the loss of energy in measuring instruments it may be well to refer to some remarks made by Mr. Edward Weston at the meeting of the National Electric Light Convention held at Washington in the latter part of February and the first of March. He called attention to the fact that the losses in central stations due to the consumption of energy in the measuring-instruments sometimes used, when figured out in dollars and cents per annum, was startling, and cited an instance which had come under his observation where the loss in this one item was $89 per year. His remarks attracked wide attention and deservedly so, as this source of loss had been almost entirely unsuspected by most central-station men.

Another class of instruments founded upon the mutual directive action of magnets and currents includes the Weston instruments. In fact the instruments of this make form a class by themselves, for while they employ both iron and magnetism as do the electro-magnetic instruments, they are not subject to the disturbing influences of hysteresis. The magnets in this case are not electro magnets, as in the other case, but permanent magnets, and the operation of the instruments is not dependent upon changing magnetism at all. The Weston ammeter consists of a permanent horse-shoe magnet having suspended between its poles a coil of very fine wire to which the needle is attached. But a very small portion of the current passes through this coil and the deviation of the needle is caused by the variation of the current in this constant magnetic field. Since the angle through which a coil will swing under these conditions is directly proportional to the current flowing through the coil and not as in the electro-dynamic instruments, proportional to the square of the current, the graduations on the dial-plate are uniform throughout the whole range of the instrument. The Weston instrument cannot be used on alternating currents, nor will it register, as some other instruments do, if the current is passed through in the wrong direction. From the fact that it measures but a very small fraction of the current, the losses due to this cause are exceedingly slight. It is also extremely delicate and sensitive, although it is what is called "dead beat," which is to say, that with sudden changes of current the needle does not vibrate much but comes almost at once to rest after registering the new conditions.

The Weston instrument is a device *sui generis* and peculiarly an American product. Mr. Weston himself is an Englishman by birth but intensely American in feeling, and takes pride in the fact that his instruments successfully compete with the best of foreign make in their own markets. This instrument and those built on the electro-dynamic principle may properly be called the chemical balances of electrical measuring-instruments.

Every electric current involves three elements: (1) the current itself, which is measured in amperes; (2) the pressure or electromotive force which gives rise to the current, measured in volts; and (3) the resistance which the conductor opposes to the current, which is measured in ohms. A current is not fully described, therefore, until all three of these elements are given, so we have instruments for measuring each of them separately. If any two are given, however, the third may be calculated from Ohm's law, which expresses the interrelation of the three, which is that the current that will flow through a given conductor is equal to the electromotive force by which that current is urged along, expressed in volts, divided by the resistance of the conductor expressed in ohms.

Thus far the instruments described are intended for the measurement of the current, and are called ammeters. Instruments intended to measure the electromotive force are called volt-meters. These latter do not differ in any way in principle from the former, and any instrument that can be used as an ammeter can also be used as a volt-meter, provided that only a very small proportion of the current is allowed to pass through it. The volt-meter, therefore, is chiefly distinguished from the ammeter of the same class in having long coils of very fine wire instead of shorter coils of heavy wire. A volt-meter is in fact a very delicate ammeter and might very properly be called a mille-ampere-meter. It is in fact sometimes so used.

Resistances are usually measured by means of an instrument known as the Wheatstone bridge. This is conventionally represented by four wires arranged in the shape of a diamond, with a fifth one, with a very delicate galvanometer in circuit, connecting the two obtuse angles of the diamond. If now the four bounding wires of the diamond have equal resistances and the two acute angles of the diamond be connected to the two poles of a battery, the current will divide, half going around one side and half going around the other side of the diamond, and there will be no tendency for any of the current to pass through the diagonal wire. If, however, one of the two wires on one side has a greater resistance than the opposite wire on the other side, some of the current will pass through the diagonal wire and be indicated by the galvanometer. If we increase the resistance of this opposite wire so that the two are again exactly equal, no matter what the resistance may be, the diagonal current will cease. Therefore, if we place the resistance to be measured in one leg (as it is called) of the bridge, and add known resistances to the opposite leg until the galvanometer ceases to show the passage of current through the diagonal, we have the exact measure of the unknown resistance. The operation is exactly analogous to weighing on a beam-balance, where the substance to be weighed is placed in one scale-pan and exactly balanced by pieces of iron of known weight placed in the other. While this instrument is of great simplicity, it is also one of great delicacy and precision.

In addition to the preceding, there are a long line of instruments of other kinds such as watt-meters, sine and tangent galvanometers, and indicators of various kinds. One of the latter class which is one of the most ingenious in the whole range of electrical measuring instruments ought to be mentioned. I refer to what is known as the Edison indicator, though for what reason it bears Edison's name I do not know, since he had nothing to do with it. It consists of a Wheatstone bridge in the two opposite legs of which are placed incandescent lamps, and in the other two, balancing coils of German-silver wire; the index-finger being the galvanometer-needle itself. The resistance of the lamps varies rapidly with the temperature, while that of the wire remains fairly constant. If, therefore, the electromotive force on the circuit varies from that for which the German-silver resistances were adjusted, the balance will be destroyed and a current will flow in one or the other direction through the galvanometer, indicating "too high" or "too low." These instruments are much used in central stations to enable the dynamo-tender to regulate the pressure on his circuits.

One of the greatest desiderata in many electrical measuring instruments is a material whose electrical resistance shall not vary with the temperature. For a long time German silver more nearly filled the bill than any other known alloy, but it remained for an American, Mr. Edward Weston, to invent an alloy having a zero temperature coefficient—which means that the electrical resistance of this alloy does not vary at all with increase or decrease of temperature. The credit for this has been usurped by foreigners, but the honor is due to America.

ELECTRICITY

Conducted by Franklin L. Pope.

ONE of the most important electrical power-plants yet undertaken, and one which is perhaps second only to that in progress of construction at Niagara Falls, is that of the General Electric Co. at Portland Ore. The falls of the Willamette river, twelve miles from Portland have a descent of forty feet, with a very large and unusually constant volume of water. The power-house, now nearly completed, is of stone and brick, with a steel-truss roof, and is 420 feet long, and 77 feet from the lower water-level to the eaves. The hydraulic and electrical machinery is divided into twenty different sections, independent of each other, in each of which is installed a 42-inch and a 60-inch Victor turbine, coupled directly to a generator of 450 kilowatts capacity. The 42-inch turbines constitute the ordinary, and the 60-inch turbines the emergency, plant. The load will ordinarily be carried by the first-named turbines, which run at a speed of 200 revolutions per minute. The 60-inch turbines are intended for use only during periods of extremely high water, when the smaller ones will be too deeply submerged in backwater to give efficient service. The aggregate electrical equipment has a generating capacity of 9000 kilowatts, or about 12,000 horse-power. An extra section contains two 48-inch turbines, carrying a pair of exciters of 300 kilowatts each, which serve the entire range of generators. The main generators are of horizontal type, and the shafts are supported upon hydraulic bearings of oil, under a pressure of 275 pounds per square inch. The weight of each shaft and its attachments is about 33,000 pounds. An oil-pump, driven by an independent turbine, forces oil into an accumulator which serves to maintain the pressure in the hydraulic bearings. The three-phase alternating system is to be used to convey power to the city of Portland, for use for general purposes.

MR. OSCAR BRADFORD, president of the Bradford Machine Co. (Chicago), writes to the Magazine his impressions, gained during a recent trip through the Rocky mountain region, of the immense force developed by the melting of the annual fall of snow, which, though now entirely wasted, might be made available as a source of energy. The section of country referred to comprises the states of Washington, Oregon, Montana, Idaho, California, Wyoming, Nevada, Colorado, and the territories of Utah, Arizona, and New Mexico. The natural resources of this section, which fit it for the support of an enormous population, have failed to attain a commensurate degree of development, largely on account of the general scarcity of fuel. This want, according to Mr. Bradford, has been compensated for by nature by providing an unlimited water-power, which science has shown us how to utilize in the generation of electricity, which may be made to render service to a large population, thus rendering the lack of fuel a matter of comparative unimportance. On the whole, Mr. Bradford is convinced that the wealth of timber, building stone, precious and other metals, and a soil capable of the highest degree of cultivation with the aid of irrigation, are well adapted to sustaining a large population, to say nothing of the healthful climate, and the absence of cyclones, due to the numerous mountain peaks which serve to break up and scatter the force of clouds and wind.

The annual deposit of snow, which is quite uniform in quantity, owing to the regularity of the moisture-laden trade-winds, melting gradually as the season advances and descending from the great heights of the mountain ranges to the ocean level, creates an inconceivable amount of power, and nature has so shaped the banks of mountain streams that sites for dams, with material for their construction close at hand, can be found at almost every mile of their length. When, by that process of mental evolution which seemingly demands a certain period of time for the incubation of a new idea, the attention of capital is once attracted to these vast opportunities for profitable investment, and the public starts in its sheep-like way on a westward stampede to enjoy these bounties of nature, it may be a serious question as to the effect upon the eastern states and their long-established industries. What will become of the coal-mines and the capital invested in them? Will the transportation companies be compelled to endure a still further reduction of traffic? Will the makers of stoves and furnaces, steam-radiators, and other accessories of heat by combustion, cease to do business? Will the factories dependent wholly upon steam-power be able to face the competition of falling water, or will they be compelled, together with their operatives, to move westward, to secure like advantages?

THE only hitherto undeveloped water-power of any magnitude on the Merrimac river—that known as Sewall's falls, a short distance above Concord, N. H.—has at length been utilized by the Concord Land and Water-Power Co., for an electric transmission plant for supplying the city of Concord with light and power. The dam is a fine structure of timber crib-work, packed with granite chips, and gives a head of 22 feet, with an average of about 5000 gross horse-power. The power-house is situated at the end of a canal 75 × 25 feet, and 1000 feet long. It contains five pairs of 39-inch horizontal turbines, set with draft-tubes, having a capacity of 400 horse-power per pair. The power is transmitted from the turbines to the jack-shaft in the dynamo-room by heavy belting, the machinery being provided with clutches, so that any wheel or section may be run independently of any other. Heavy fly-wheels are used to prevent the sudden speeding up of the turbines upon a reduction of the load, before the governors have time to act. Two large tri-phase generators, out of the six which are ultimately to be employed, are already in place and at work. These are separately-excited machines of 250 kilowatts capacity each. Each generator is driven from the jack-shaft by a 36-inch belt at a speed of 600 revolutions per minute. The current is generated at a potential of 2500 volts, and is conveyed directly to the step-down transformers, which are centrally located at a point in the city three miles from the power-house, by overhead copper wires, with a fall of potential of 300 volts. The network of distribution and consumption circuits in the city is worked on a potential of 110 volts at the secondaries of the transformers. The company is at present supplying in Concord about 5000 incandescent and 300 arc lights, as well as 400 horse-power of motors, and about 30 kilowatts for heating, cooking, and miscellaneous uses.

THE efforts of the General Electric Co. to arrogate to itself the control of all the electrical industries of the United States —the avowed policy with which it entered the field some two years ago—has apparently not been attended, thus far, with distinguished success. The annual report recently published shows that the surplus of over $1,000,000 reported a year ago has given place to a profit and loss debit of some $12,500,000, representing the impairment of capital by shrinkage of assets during the twelve months. Nevertheless, among the assets scheduled in the present report is one item of over $8,000,000 of "patents and franchises." It does not appear that these patents and franchises have hitherto seriously impaired the capacity of rival companies to do business in the electrical field, and the prospect of any such consummation hereafter seems to the disinterested observer to be daily growing more and more remote. But in spite of this depressing exhibit, a company which, in such a year as we have just passed through, can show net earnings of $2,250,000 above fixed charges, is by no means in a hopeless condition. The era of reckless speculation and inflation in electric enterprises, though probably not yet at an end, inasmuch as the inevitable crash in the street-railway business is yet to come, is certainly drawing toward its close. The day is not far distant, when manufacturers of dynamos, motors, and other electrical machinery will have to come down to hard-pan, and sell their wares on their intrinsic merits, and at the ordinary manufacturers' profit, as steam-engines and wheelbarrows are sold. The possibility of any monopoly in the electrical business, except possibly that of some cheaper apparatus or process than any of those now existing, which may hereafter be discovered, has apparently passed away forever.

THE new Atlantic cable which is now being laid in sections between Ballingskelligs bay, Ireland, and Canso, Nova Scotia, for the Commercial Cable Co., is in many respects a notable piece of work. The cable is about 2100 miles in length; its conductor contains more than 1,100,000 pounds of copper, and is armored with over 10,000,000 pounds of steel wire. A considerable portion of the copper is from the Trenton works of John A. Roebling's Sons, and this is, we believe, the first instance in which wire of American make has been used in the manufacture of the conductor of an Atlantic line. The calculated rate of transmission by the new cable is thirty words per minute, which is greatly in excess of that of any of the lines now working, the average speed of which is probably not above eighteen or nineteen words per minute. This increased capacity is due to the great quantity and unusually high conducting power of the copper used in the core. The line is being laid by the *Faraday*, a large steamer constructed expressly for this kind of work, and owned by Siemens Brothers & Co., of London. The heavy shore-ends are to be first laid, 100 miles extending westward from the Irish coast, and 400 miles across the Banks of Newfoundland. These are expected to be completed in time to lay the mid-ocean or deep-sea portion during the fine weather which usually prevails in the north Atlantic during the first two weeks of June. Like all modern cables, the new line will be operated on the duplex system, by which transmission is carried on simultaneously at full speed in both directions.

IN the annual report of the Massachusetts railway commissioners for the current year, an interesting comparison is made between the cost and earnings of the horse-railway systems of 1888 and the electric-railway systems of 1893, as taken from the official returns filed with the commission. The percentage of increase in net earnings is given as follows: per passenger carried, 62.5; per car-mile run, 73.56; per round trip, 85; per mile of railway, 57.44. On the other hand, the percentage of increase in cost of railway per mile is 60.2, and in capitalization per mile 65.2 per cent. The commissioners point out that an increase of 65 per cent. in capitalization, and of only 57 per cent. in net earnings, does not make a very favorable showing for the electric system from a financial point of view. It is also suggested by them that, inasmuch as the electric plants are all new or nearly so, the cost of maintenance chargeable to operating expenses must thus far have been abnormally small, and the consequent exhibit of net earnings abnormally large. Ordinarily this would doubtless be true, but the fact is that two or three or more new sets of motors have been substituted for others within the period under review in consequence of improvements in design, the cost of which has doubtless gone in most cases, into the maintenance account. The standardizing of the electric machinery which is now going on will, in our opinion, tend largely to reduce the maintenance account in future years. It is clear however, that the electric railway offers but little margin for bad management or waste of any kind, if ultimate financial disaster is to be averted.

THE Boston Fire Underwriters' Union insists upon the requirement that every piece of insulated wire which is to be used in that city for conveying electric currents for lighting and power purposes shall be subjected to an insulation test before it can be placed within a building. H. C. Cushing, Jr., in a paper in the *Electrical Engineer*, states that these tests show that it is only within the last two years that uniformly excellent insulated wire has been attainable. The samples examined since March, 1888, have come from something like fifty different manufacturers, and the records of the tests, all of which have been preserved, have shown a vast improvement in each successive year, as to quality of wire, insulation, finish, and power to withstand abrasion. The samples tested in 1888-89 were extremely variable in quality. Many of them exhibited flaws, pin-holes, and non-homogeneous coatings of insulating material; a state of affairs which is shown by the more recent tests to be rapidly disappearing with the introduction of modern improvements in manufacturing processes. Most of the improvement has been made within the past two years, and the goods of the leading manufacturers are stated to have now reached a degree of perfection considerably in excess of the requirements of the underwriters. Owing to this thorough system of inspection, which insures an electrically perfect wire, there would seem to be no possible chance for a fire to originate from any defect in the conductors, if wiremen and inspectors do their duty in accordance with the present rules and requirements of the Underwriters' Union and of the New England Insurance Exchange.

IT is reported in the newspapers that the Bell Telephone Co. of Canada has brought an action against the Montreal street-railway company to recover $27,000 damages, for expenses incurred in placing return-wires on their lines; the former use of the earth being rendered impossible by the interference caused by the electric railway circuits. The legal contention of the telephone company appears to be that it has obtained, by long usage, a vested right to the use of the earth for the purposes of its business, of which the action of the railway company has deprived it. We do not recollect that this particular point has been settled in any of the somewhat numerous suits between telephone and railway companies which have been litigated in the United States. We imagine that a coterie of gifted attorneys and experts might be able to find a great deal to say on both sides of such a question. If the English doctrine of "ancient lights" is accepted in Canada, we should think it might be invoked as a somewhat powerful analogy in support of the position taken by the telephone company. The case seems likely to be an interesting one, and we may have more to say about it.

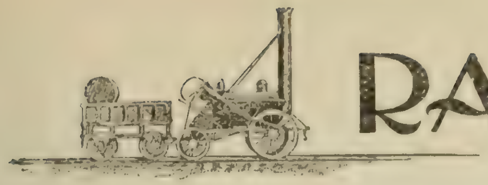
THE American Institute of Electrical Engineers has taken a very important step in the formal adoption, at its March meeting, of the provisional magnetic units which have for some time been before it for consideration. This system should not be confounded with that under consideration last summer by the Electrical Congress at Chicago, in which a not altogether successful attempt was made to correlate the proposed magnetic units with the accepted electrical units, by assigning to them arbitrary magnitudes. The severe criticism with which this proposition was met from the best authorities on all sides apparently has had the effect of bringing forward the far preferable system which has now received the sanction of the Institute. The new provisional system certainly seems well adapted to the needs of practical workers, and, although it may possibly have to encounter some adverse criticisms from expositors of pure science, yet if it should be fortunate enough to find favor in electro-technical circles, its ultimate adoption will be but a question of a short time. There was quite a lively discussion among the members of the Institute upon the question of nomenclature, the majority favoring the use of terms derived from proper names, as has hitherto been the accepted custom in reference to electrical units, and the minority contending that Greek derivatives were preferable. Messrs. Houston and Kennelly, in a recently-published communication, have proposed to lessen the inconveniences arising from the small dimensions of some of the units in common use, by employing prefixes to denote large multiples, such as "bega" for million, "trega" for one trillion, etc., and for sub-multiples, "bicro" for one billionth, "trico" for one trillionth, etc. This seems a very sensible suggestion, and we have no doubt that it will find ready acceptance among electrical engineers.

THE commonwealth of Massachusetts is at present represented, or rather misrepresented, in congress, by one Walker, who, if we may judge from published extracts from his speeches, would be much better off if he were relegated to some retreat for the restoration of disordered mentality. In a recent speech in the house, he railed wildly at the builders and owners of trolley railways, calling them, among other things, "a cruel, heartless, remorseless combination of interests, that has no regard for human life, or the comfort of citizens." Referring to the Westinghouse, General Electric, and other leading manufacturers of street-railway machinery, he asserted that "these great dominant unprincipled combines" had pursued the conduit system of street-car traction "with the malignity of the infernal regions." Not content with this ridiculously false assertion, he proceeded to vilify the electrical engineers of the country—who, we may parenthetically observe, are, as a body, at least as respectable and as respected as the one which is compelled to listen to his own insane outbursts—by making the preposterous assertion that "this monstrous devil-fish has in its pay every electrical engineer of this country, retained in its own cases, who is of sufficient reputation to have his head at all above the common level of electrical engineers; and you cannot get an opinion out of any of them." In reply to this, it may be observed that, if the Westinghouse Company, or the General Electric Company, or any individual electrical engineer could get control of a successful conduit system for electric railways, they would have in their hands "a potentiality of wealth beyond the dreams of avarice." We are afraid that Mr. Walker is a fool.

ACCORDING to the returns of the census of 1890 there are in the United States 313 electroplating establishments, representing a capital of $33,838,549, and employing 2162 operatives. The annual value of the product is $3,121,642.

IN a paper recently published in the *Electrical World* on the transformation of alternating currents, Charles P. Steinmetz contends that, in electrical distribution, anything that can be done by one polyphase system can also be done by any other polyphase system, and in most cases by a single-phase system; hence he argues that in these days there exists no good reason for using polyphase systems for electrical light- and power-*distribution* only, in place of the low-frequency single-phase system, which, by reason of its simplicity and convenience of regulation, he believes to be far superior to any polyphase system. The proper sphere for polyphase systems, in the opinion of Mr. Steinmetz, is in long-distance power-*transmission* at high potentials, in which the tri-phase system offers the important advantage of a saving of copper of over 25 per cent. over the single-phase alternating system, and even this may be increased if the line has been designed to comply with conditions of maximum economy, as pointed out, among others, by Professor George Forbes.

A VERY successful example of the application of electric locomotives to mine-haulage is that in use in the Bear Run mine of the Blossburg Coal Co., in Tioga county, Pa. Two locomotives are now in service, each propelled by two motors, one on each axle, aggregating 30 horse-power. Each locomotive weighs 7500 pounds; is 9 feet 6 inches in length, and stands only 31 inches above the rail. The draw-bar pull is 1500 pounds, and the usual speed about six miles per hour. The track-gage is 36 inches. An 80-horse-power engine drives the generator for supplying the current to the locomotives. A maximum load can be hauled by these locomotives of thirty-two loaded mine-wagons weighing 3200 pounds each, in one place up a 3-per-cent. grade. Each locomotive averages a daily haul of about 650 tons. The substitute of the electric system for the mules formerly employed, has effected a notable economy in the cost of haulage, particularly as the machines occupy so little vertical space that they can go into many headings which were wholly inaccessible by animal power.



RAILWAYS

Conducted by Thomas L. Greene.

THE speculative opinion in Wall street seems to agree with the view expressed by President J. Edward Simmons, in the Magazine for April, that the turn in business affairs had come, and that there is warrant for confidence in the future. Quotations for the very best bonds have been high all winter, but there has been lately a pronounced advance in the prices of bonds and stocks previously considered somewhat doubtful. If any one cause more than another is to be named for this confidence in railway securities on the part of the speculative and investing public, it it the radical reduction made in operating expenses. The public have made up their minds that because of these reductions the railways will continue to pay their old fixed charges or dividends until the gradual resumption of business activity shall enable them to return to their old-time expenditures. To business men and others dependent directly or indirectly upon the prosperity of the railway for their own trade and profits, it may seem at first as if this later and further reduction in expenses was an additional blow to them. While this may be true for the moment, it is nevertheless a fact that in no other way could their trade with the railways be secured for the future. Railways are dependent for future improvements on their credit. The recent advance, therefore, in the quotations for their stocks and bonds is an assurance that the capitalists of the country have a returning faith in them as business enterprises. In time to come the corporations can make use of this faith to draw from investors further money with which to build extensions, improve their road-beds and equipment, and, in general, return to their former activity. While such operating savings at first sight appear to be against the interests of the employés of the railroad and of those from whom it purchases its necessary supplies, yet to those who will look beyond the immediate future it will be seen that in no other way could the business problem of the railways be arranged. The passing cloud, therefore, has a silver lining.

These railway economies differ on different roads. Some are clearly legitimate—perhaps a majority of them. One company is sending out its trains with one brakeman short of the usual number. The remaining brakemen are told that if this plan for reducing the operation expenses should fail the wages of all will be reduced to a corresponding amount. The brakemen in service appreciate the situation, and, so far, by the exercise of special diligence, have prevented any disaster to the trains from lack of help. Of course, the air-brakes help the road greatly in its experiment. Other companies arranged for a year or more before the World's Fair to put their house in order for that event. Road-beds, cars, and engines were, during the year, brought up to an unusual degree efficiency. Now that the Fair is over, the expenditures of the last two years have been sufficient to leave the property in such condition that many of the ordinary repairs can, for the time, be omitted without reducing the plant below the normal standard. In this sense it is true, as stated by many companies, that, in spite of the decline in operating expenses, the property has been kept in good condition.

Certain classes of repairs have, however, only been postponed. A road which, owing to the dull traffic, has use for but three-quarters of its equipment, and which allows the other one-quarter to stand idle on the side-tracks, is always tempted to throw on to the siding a car which has been crippled, and to draw a good car for the daily service. In this way it may come about that the idle cars standing on the side-tracks will every one need repairs before they can again be put in use.

When the railroad managers see signs of a revival in general business they will be obliged to spend money freely—if they can get it—to repair the cars then needed, or else to see rival roads with better credit carry away the competitive tonnage. It is something of this sort which President Perkins, of the Chicago, Burlington and Quincy railroad, refers to in his annual report for 1893, when he speaks of "temporary economies, postponing where it could be done without impairing the safety and efficiency of the service, the expenditures which should properly have been made." The same matter was referred to by President Chauncey M. Depew, of the New York Central railroad, in the speech before the Trunk-Line Association when he said: "We cannot long maintain present economies. If we add lower rates the drain upon our roads will cost us an enormous amount, either in additional expenses or in issuing bonds to put us a year hence back where we are now." But in any case, the saving of expenses both legitimate and illegitimate is laying the foundation for a better credit in the future when the railways shall feel in effect the better times which the market is now enjoying in anticipation.

It is well to turn for a moment from our own home affairs to glance at the position of railways which are radically different from our own. The director-general of railways for India has made a report for the fiscal year ending March 31, 1893, which has been printed by the British government. India, like Russia, being a debtor country, must pay its debts abroad in exports, and for this purpose the governments of both Russia and India find it advisable to encourage, and even to force, the sale of wheat abroad. In India the average yield to the acre is about nine bushels, which is often carried forty or more miles to the railway-station. From there to the port of export the haul on wheat is from 800 to 1000 miles, at the average rate of five mills per ton per mile, almost exactly the charge and the distance of our own trunk-lines from Chicago to the Atlantic seaboard. Wheat which is within 300 miles of the port is charged three times this price per ton. While the railways in India carry wheat at about the same tariffs quoted by American railways, their other charges are very high, ranging in the highest class from 4 to 7 cents per ton per mile,—nearly five times the charge of the American roads on dry-goods from the Atlantic seaboard to the Mississippi river.

But it is in the passenger service that the greatest differences appear. In the United States the freight revenues greatly exceed those from passengers, but in India the reverse is the case. Moreover, fares in India must be proportioned to the low standard of wages prevailing in that country, so we find that for third- and fourth-class passengers (natives) the fare is but ¼ cent per mile, or say from $2.50 to $5 for a trip from New York to Chicago. By far the greater part of this cheap travel is for short distances, and the low price of two cents per ticket is charged between stations not far apart. The railways recoup themselves for these low fares by running slow trains at infrequent intervals (but one a day in some cases) and crowding them to the utmost; thus the average number of passengers per train in India is over 200, and on one road the average is 274. We can realize how crowded the trains must be when we compare these averages with the United States average of 42 passengers per train-mile. Thus in India, in spite of the low fares charged to the natives the earnings per train-mile are about $1.05,—nearly the same as in the United States. The working of the Indian railways requires over three times as many employés per mile as in the United States, 96 per cent. of whom are natives, who have been slowly replacing Europeans in the minor positions of trust, such as station agents, engine-drivers, and the like. The coal problem is serious in India so that the government has made unusual efforts to develop the fields existing. One or two of the companies import their supply from Cardiff, Wales, at a cost of from $4 to $7 per ton. These figures and costs in United States money are all based on the official value of the rupee in the fiscal year, given in the report as 1 shilling 4 pence,—or about 33 cents. At present silver quotations a rupee is worth 8 or 10 cents less than that figure, so that the tariff charges at the present time are in fact lower than the range of rates already given. This fall in the silver value of the rupee causes a heavy deficit on those Indian railways which are worked by the state or under state guarantee. Capital for the Indian railways has been furnished from England, and the fixed charges are payable in gold. The fall of exchange in 1893 cost the government more than $3,000,000 for its railway guarantees, exclusive of sinking-funds. The average earnings per train-mile on the Indian railways are given as $1.40, the working expenses (47 per cent.) at 64 cents, and the net earnings 76 cents. These results, in spite of the great difference in details, are somewhat similar to the results on American railways, and furnish a curious proof of the fact that capital employed through large corporations will endeavor under any difficulties, to get its usual profit.

THE agricultural department at Washington has sent to the different railways a circular letter advocating the giving of more attention by the railways of the United States to common roads. That better wagon-roads are worth all they cost is generally admitted by those who study the subject, though it is not easy in all cases to tell the saving in dollars and cents. So much depends upon the peculiar circumstances of each farmer that no average estimate of the value of a good road can be made. If a farm is so poor or so inefficiently worked that the farmer can postpone the drayage of his products to the railway-station from a muddy day to a dry one, of course he is not so much concerned in having good wheeling in rainy weather; but then, neither is he a good business man.

The converse of the proposition is equally true. The railway company which transports the ambitious farmer's produce to market is interested with him in having wagon-roads good enough to admit of the cheapest drawing of that produce from the farm to the railway-station. It is estimated that grain, hauled an average distance of five miles to the railway-station, costs the farmer an average of $1 per ton; and while the saving under this amount by having good roads and by the use of broad tires will differ in different cases, yet anything which will reduce the cost of producing grain, or rather, give the farmer more profit, is a benefit to him and an indirect benefit to the carrying companies which depend upon the farmers' prosperity for their own. Good roads have also the indirect effect of increasing the productiveness of a railway company's tributary territory. The reason here briefly given in favor of better wagon-roads is sufficiently sound to warrant the railways in paying more attention to this subject. Indeed, they might with propriety take an active interest in the movement for good roads which is now slowly spreading throughout the country, and, when times are better, could afford to devote a part of their net earnings toward sharing with the farmers the expense of improving the common roads leading to the stations.

The common roads of Europe, as in Switzerland and Norway, are the principal highways of national communication. Railroads take their place, to a great extent, in the United States, so that the argument for good roads with us rests upon their value as feeders to the railways rather than upon their necessity as means of interstate communication. The cost of good roads may be set down as from $2500 to $5000 per mile, and if we estimate that farming land a mile back from the turnpike will be favorably affected, the cost of the new road per acre would be, say $2.50, and the requirements for maintainance of the road per acre about 25 cents annually. It is too early yet to say just how these sums should be divided among those benefited, but it is clear enough that the railroads might well become active in promoting the movement, and for their own advantage might contribute their share toward the expenses.

THE lately-threatened dissolution of the Southern Railway and Steamship Association has called attention anew to the importance of these associations. The Louisville and Nashville company found its percentage of certain traffic slowly declining; thus its proportion of pig-iron and manufactured iron from the Birmingham, (Ala) district for the six months ending December, 1892, was 53 per cent. while for the corresponding period of 1893 it was but 45 per cent. The president of the company charged this loss to the rate-cutting of competitors, and straightway gave notice of withdrawal from the association, a notice which, if carried out, would have meant a rate-war throughout the South and for all southern lines. Without expressing an opinion upon the merits of the case as presented by President M. H. Smith, of the Louisville and Nashville railroad, it is proper to say that it was a grave error of judgment to give notice of withdrawal from the association without first using the machinery of the association in an attempt to cure the evil complained of. Under the stringent provisions of the interstate law, railway associations now find it one of their high duties to act as arbitrators in disputes between members, to smooth over difficulties, and to remove those misunderstandings which may have no foundation in fact, but which are as fruitful a source of cut-rates as though they rested on good grounds.

After a session of a week or more in New York city, during which a full discussion of the grievances was had, the Louisville and Nashville Railroad Co. cancelled its notice of withdrawal, upon the agreement of the other lines to look carefully into its complaints. This action of the complaining company was right and proper. Associations have no reason for existence if they cannot be made use of by the members in case of an emergency. Traffics are poor on our railroads now, and if to this is to be added a war of rates—which under arbitration could be prevented—then it is time that the owners of railway stocks and bonds should exert their influences to save so much of the revenues of the companies as the hard times have left for them.

THE bill introduced into congress to change the clause making violations of the interstate law a misdemeanor for which railway officers could be sent to states prison, and to make such violations punishable only by a fine to be collected from the corporation, is a bill whose passage will go far toward remedying one of the weak spots in the act to regulate commerce. No subordinate railway officer will give a lower rate to one merchant than to another except by direct orders of his superior, or at least through a tacit understanding with him. The real responsibility for the action of each company on rate questions must rest upon the president and board of directors. It is worse than useless—it is unjust—to attempt to punish subordinates under these circumstances. Furthermore, no railway man, when put into the witness-box, will give evidence against a brother railway officer, though the latter may be employed by another company, because he knows that the offense is not justly chargeable to that subordinate alone. In the light of Judge Grosscup's decision, which seems good law and good sense, no railway man need testify about any transaction to which he is a party, because his testimony could certainly directly or indirectly be used against himself. On the other hand, the feeling of railroad men for each other does not extend to the competing road. If that competing road has been giving secret rebates, the officer of its rival will generally be willing to put his evidence before a court of justice, provided it is the corporation and not the subordinate officer which shall suffer the punishment. Thus, from all points of view, it would be much better to have the punishment for violations of the interstate commerce law visited upon the companies and not upon individuals; and this is what the bill now before congress proposes shall be done.

THE report of the railway commission of Massachusetts for 1893 contains as usual many interesting tables and much valuable discussion. One fact referred to in their report may be mentioned here. In two years the crossings of steam railroads in Massachusetts by electric street-railways have increased in number from 26 to 100. The board remarks that such crossings should be permitted, if at all, only under careful regulations, similar to those which experience has proved to be necessary in regard to the crossing of railroads on the same level. "Of all the perils which attend travel on railways there is no one which, in the apprehension of the board, is so serious, both in its character and extent, as that here pointed out." The same subject is referred to in the annual report of the railway commissioners of Connecticut, while the danger of such crossings is made the occasion for remarks by President Roberts of the Pennsylvania railroad in the annual statement of that company. The railway community, at least, is awake to the great perils which would come from the threatened increase of crossings at grade of steam and electric roads.

THE petition for the removal of Receiver Oakes, of the Northern Pacific railroad, alleges that that gentleman, when president, promoted, or allowed to be promoted, many industries along the line of that railroad, out of which the directors and officers of the company made handsome profits. Without discussing at this time the merits of this particular case, it is well to state in few words a phase of the general subject which has not received much attention. The Northern and Union Pacific railways were chartered by special acts of congress thirty years ago. These charters provided for a single piece of road from one specific point to another, and nothing else. Our modern charters give railways the power of building additional lines and doing such other acts as are necessary for the development and operation of the road as a business. In the cases of the two roads named these powers are present in the charters only by implication. Even the legality of the guarantees upon branch-line bonds made by these two companies depends upon this implication, which has to be read between the lines, as it were. Ever since they were built, the managers of these two roads have been dependent for success upon increases in their traffic, brought about to a large extent through their own exertions. Everything was new and uncertain. The officers were required not only to manage the railroad proper, but to encourage the opening of new industries along the line. In short, by their positions they were compelled to be promoters of the general industrial prosperity of the states served. While this development of the country pressed upon them on the one hand, they were debarred by their charter from doing any of these things through the company itself. Anything, however necessary or however conducive to the interests of traffic, must either be left to the slow working of commercial forces or be engineered by the directors and officers of the company who know the circumstances and the needs better than any one else. These gentlemen were in a number of cases compelled thus to put their money into branch-roads, elevators, or mines before the ordinary Wall-street banking-house would think of investing. No railroad man has a right to speculate in the stock of his company for the decline, since such speculation would create a business interest adverse to that of the corporation; nor should he lend his aid in unloading upon the company worthless properties at exorbitant prices. But, on the other hand, it not only might not be wrong for him to invest his money in industries along the lines of his road, but it might be in the highest degree unselfish for him to do so; for the railway company might be benefited a hundred dollars where his profit would be but ten. In such cases his interest is not adverse to, but in accord with, that of the railway. In short, it is not just to say that investments should not be made by directors and officers along the line of their road, particularly in a new and developing country. Every such investment before the bar of public opinion must depend upon its own merits. The great increases in the traffic of the Northern and Union Pacific railroads, until last year, were owing to the business developed in part by the efforts of those interested in the property; while their failure to meet their interest charges for the year 1893 was due to other causes, not connected with this question of the development of contributing industries.

THE question of uniformity in railway bills of lading seems, like the poor, to be always with us. The boards of trade of the different commercial cities have been pressing a movement against the railways because of the forms of bills of lading which they, through their associations, recently adopted. This form made the railways, as common carriers, practically responsible to the shippers of freight for none of the losses and damages arising from transportation. Such a contract, it is well settled now, is not binding in law. With the one exception of a decision by the court of appeals of the state of New York, which seemed at the time to look in an opposite direction, the state courts have always held that a common carrier cannot make a contract which shall exempt himself from losses caused by his own negligence. This decision has also on the ground of public policy received the approval of the supreme court of the United States and may be now considered a part of our system of law. This being the case, no bill of lading could save the railroad from payment for losses for which it is and ought to be responsible. Why, then, should the illegal form of bill of lading be insisted on by the companies? The object seems to be two-fold: first, to escape the payment of claims presented by small shippers who are ignorant of the law, and who may be frightened off by the language of their bill of lading; second, to keep up the appearance of non-responsibility with the hopes that what the companies have always contended for they may in part eventually obtain. An observer, however, must see that this latter hope is a faint one; and asfor the former reasoning, that certain shippers may fail to collect claims for honest losses, the position of the railways must be condemned by all right thinking people. Legislatures are often hard upon railways, but the common law is not, and with the safeguards granted by the method of releasing shipments and by the practise of carrying goods at owners' risk, the railways would fare as well as any of their customers by trusting themselves wholly to their common-law rights.

Exempting the carrier from certain specific losses arranged for by the signing of a release is a custom which yields to the railroads only what rightfully belongs to them. The carrier should be responsible for the losses arising from its own particular business of transportation such as damages from collisions, but it should not be held liable for losses which come about through the nature of the goods themselves; such, for example, as the fermenting of molasses or the damage which a horse, for illustration, may do himself in a car, or the losses which occur through the shaking of the goods, a thing which is inseparable from the mode of transport. It is also proper that lower rates should be given on articles shipped at owner's risk, covering for example, rust on manufactured iron arising from exposure to rain; provided, again, that the company has not been negligent.

AS showing the value of the railway interests to the English manufacturers, and as exhibiting also the depression which is now prevailing to a greater or less degree throughout the world, the following table, copied from an English paper, gives the values of the locomotives exported from Great Britain to the countries named for three years:

	1891.	1892.	1893.
Russia................	£ 1,374	£11,552	£13,746
Germany.......... .	14,985	8,888	3,403
Belgium	1,968	7,474	1,151
France........	8,674	8,556	10,047
Spain and Canaries..	105,581	49,527	21,421
Other countries in Europe............	156,642	172,150	48,722
United States.........	13,253	2,382	16,336
South America......	455,593	182,623	139,726
British Africa........	78,995	97,171	81,034
British East India ..	336,061	159,983	346,073
Australasia	308,385	216,682	85,762
Other countries......	135,744	66,764	84,638
Totals........ ...	£1,617,254	£983,752	£852,059

Except for the increase in 1893 over 1892 in the engines shipped to British East India, the decrease would have been much more marked. The increase shown in shipments to the United States is doubtless to be accounted for by the exhibits for the World's Fair.

ARCHITECTURE

Conducted by Barr Ferree.

THE difficulties of conducting architectural criticism in the columns of a real-estate journal have seldom been more amusingly illustrated than in some recent issues of the New York *Record and Guide.* As a real-estate journal this weekly paper is quite without a peer in America, and has won itself a name of enviable excellence in its own special field. It seeks to illumine the dull statistical tone of real-estate essays by printing, from time to time, comments on architecture, that being an allied topic. It is sometimes wickedly suggested, in semi-literary circles in New York, that the dramatic criticisms of one of the greatest of the metropolitan dailies are composed by an ancient Apple Woman, who passes her days behind a stand closely adjacent to the offices of that organ of culture and light. We presume that the *Record and Guide's* recent criticism on the new Metropolitan Club house in New York was composed by the thrifty Italian who sells sweets and other alleged delights close by the door of that journal. Such remarks as "the Dago murders repose" and a reference to Italian journeymen recall Mulberry Bend rather than the sober remarks of a sober critic. And that gentleman—if it be a gentleman—finds the building "as nearly devoid of architecture as a factory. It shows no composition except in the proportioning of the stories to each other, no features, and no detail except that of the balconies and the cornice." Verily, what should have been given us? Should there have been variety for variety's sake? A breaking of lines, a mixing of masses, an elaboration of ornament simply to please the Dagoish mind of the real-estate critic, who, by the way, would rather the building were of brown stone than of white marble? The trouble with this critic is that he was not consulted in the beginning. Architects would save themselves many sleepless nights and painful hours if they would remember always to consult the critic beforehand. He invariably knows so much better what to do than any one else that it should be a pleasure for the jaded architect to seek inspiration at his hands, instead of awaiting condemnation after everything has been completed. But this is neither here nor there. The Metropolitan Club house is doubtless fully satisfactory to those who made it and who use it, and who else need be consulted? It is very far from being a faultless building, but it certainly does not deserve the thoughtless remarks to which we are directing attention. Were we to classify them we should certainly call them Paleozoic criticisms, for no modern man in touch with live ideas could have written them. Now mark the tribulations of the real-estate critic. The very week after condemning one of the most beautiful and scholarly buildings in New York the worthy paper saw fit to spread itself on the "beauties" of the Dekker building, distinctly one of the most distressful edifices in America. "Its bright, lofty, ornate façade enjoys from the square what is possible with but few of the modern high office-buildings—a good perspecttive," it writes. "This was doubtless an inspiration to the architect . . . . The offices are finished in style to harmonize with the highly artistic exterior." Thus is art encouraged by the leading real-estate organ in America. We should be inclined to say that it was paid for the last remarks, and paid some one for making the former ones, were it not for the reference to internal and external harmony. This was one of the strong points of the critic on the Metropolitan Club, only that there they did not harmonize, while in the Dekker building he gives us his word that they do. The fine mind of the Italian dispenser of sweets is observable in both productions. We shall enshrine both these effusions in our collection of curiosities of criticism, and herewith place them in an exalted nook.

MR. THOMAS HASTINGS has been delivering some lectures on architecture at Harvard University, where he has made a profound impression by the earnestness of his discourse and by the charm of his enthusiasm. This is quite as it should be, and the students at Cambridge and the good people of Boston generally are to be congratulated on having secured the instruction of one of the most capable and distinguished architects of the day. Mr. Hastings's work is not always of that evenness that is to be expected from so thorough an artist and so accomplished an architect, but he has already—with many years of progress and study before him, God grant—accomplished a vast deal of delightful work that has given ample evidence of a rare artistic feeling. His utterances on architectural questions are therefore entitled to the widest hearing, and this we have no doubt will follow from his recent discourses at Harvard. Mr. Hastings represents, however, but one side of the current architectural thought of the day. He has so steeped himself in the Renaissance that he can represent only that one form of architecture, albeit one of the most interesting and varied. And he is not to be thought the less of on that account ; for he has not only the courage of his convictions, but—a rare thing among American architects—the ability to defend them with unusual vigor and skill. However we may differ with him in the question of style, we can at least admire him for this quality and recognize the earnestness and thoroughness of his work. At the same time it would be well for the Harvard authorities to bear in mind that he has shown them only one aspect of current architecture. Having now taught the Renaissance by means of one of its most brilliant practitioners, it behooves them to cast around for some one to tell them the other side. And they will have to look far to obtain so satisfying a representation as Mr. Hastings has given them of his school.

THE collapse of the effort of the American Institute of Architects to induce the secretary of the treasury to put into practical operation the law authorizing competitions for government buildings is quite the most serious blow that venerable society has met with in its long existence. The correspondence in the matter has been made public and all those interested in the case are doubtless entirely familiar with its details. The unexpected ending to so many years of labor—for the efforts of the Institute towards this end have been its most important occupation since its organization—must be a matter of regret to all parties. It is quite natural that the president of the Institute should feel aggrieved over the results of his labors, but dispassionate reading of the correspondence clearly shows that if it was not conducted throughout on the most courteous lines, the discourtesy was not one sided. To begin at the beginning, the directors of the Institute acted with somewhat unnecessary haste in condemning the plan for the Buffalo building, out of which the whole controversy has arisen, on the strength of a newspaper cut. No architects ever before undertook to pass judgment by architectural illustrations in the daily press, and the decided criticisms made on this most undecisive evidence doubtless created ill-feeling in the offices of the secretary of the treasury and in that of the supervising architect, which very probaby influenced the whole tenor of the later correspondence. The supervising architect, on his part, need not, perhaps, have written just the letter he did in reply to this communication, which appears to have been properly enough referred to him. But he was clearly within his rights when he wrote it, which his opponent as certainly was not in demanding its withdrawal before anything else could be considered. All of these things are small matters, but on both sides a tendency towards dogmatism early developed that culminated in acrimony towards the conclusion. Business men, so far as our knowledge goes, do not tell each other their respective communications are insulting, if future business relations are anticipated. Neither do men asking a favor, or for the adoption of a plan devised especially in their interest, assume a defiant tone. The secretary of the treasury was clearly within his lawful rights in refusing to follow the suggestions of the American Institute of Architects. Architects are prone to anger towards those who do not agree with them, and the present case has proved no exception to the rule. The chief crime of the secretary has been, not so much his refusal to cancel work already accomplished on the building for Buffalo, but in presuming to pass judgment on an alleged point of architectural interest that did not agree with the advice tendered him by the Institute. But the whole thing is terribly regrettable. The Institute is now further back in public estimation than it ever was. The treasury department has definitely announced that it will not act on the permissive legislation passed by the last congress. And that is where the matter stands. The case is very much like that of the inventor: he has a fine idea for the other man if he can only convince him of it. The Institute had an idea and wanted it put into effect, but was unable to convince the necessary official of the value and efficiency of its proposals. It is to be hoped that the Institute will not waste valuable breath in berating the honorable the secretary of the treasury. Rather let it devote itself to strengthening its views and arguments, so that when next a favorable opening occurs to help on the reformation of government architecture in America, its position will be absolutely impregnable. And when this time comes, as it may, we would suggest that the correspondence of the Institute be couched in terms which recognize the right of the treasury department to exercise its own discretion in the matter, unless, perhaps, a new law shall have been put into effect. The present correspondence was conducted wholly by the president of the Institute, not by its secretary.

JOSEPH'S historic coat of many colors would have seemed a very sad-colored garment indeed had it been placed in the rooms in which the department of architecture of the Brooklyn Institute of Arts and Sciences held its recent third annual exhibition. The walls literally blazed with color, and so brilliant was the effect that it seemed almost impossible not to think some fresh tints had been invented for the occasion. In a collection of this sort, confessedly for the benefit of the unenlightened "public," and conducted with so much regard to color, few really architectural drawings were to be looked for. The most notable of these was a line drawing from Messrs. McKim, Mead & White, of Bates Hall, in their Boston Library building. The value of this splendid piece of work was somewhat offset by the picture of their new Brooklyn Museum, with the extraordinary sky, which was shown for the first time in the last League exhibition. If our memory serves us aright there were but three plans in the whole exhibition, but an abundance of Turkish and Persian rugs, some good pieces of old furniture, Japanese umbrellas, vases, pedestals of costly marble, pictures, cartoons, decorative schemes, real and alleged; everything, in fact, needful for an architectural exhibition, as such things are now conducted, but architectural drawings. The number and variety of the water-colors scarcely compensated for the lack of real things for the architect, but they served to point the present absurd tendency towards color in all sorts of drawings for all sorts of purposes. But if the Brooklyn exhibition was lacking in architectural drawings, it certainly achieved the distinction of being the most brilliant collection of the kind brought together up to date. It is always something to have done what was never done before, even if it is not the best thing imaginable, and a certain distinction is given to any one who achieves the utmost in any one direction. From this standpoint, therefore, the Brooklyn exhibition must be pronounced an extraordinary success. It is to be hoped that, in time, the real meaning and nature of an architectural exhibition will be comprehended in that city; meanwhile she is to be congratulated on having done the best that she could, and having done it well according to her lights.

NO city on the globe is more in need of an architectural school than the good city of Philadelphia. That ancient and quiet town boasts the possession of more architectural wonders than may be found elsewhere on the same area, and it is quite in the proper order of things that an architectural school should flourish in their midst. Yet, strange as it may appear, the School of Architecture of the University of Pennsylvania, which is rapidly becoming the center of architectural interest of what is now called by many optimistic persons "New Philadelphia," has been founded with the idea of showing Philadelphians the real abominations of their own handiwork. In other words, there is growing up in Philadelphia a real and important School of Architecture that bids fair, in a very short time, to equal in importance any of the older schools in the country. Never was there greater need for such an institution; never was a broader field opened to a body of reformers. The School of Architecture of the University of Pennsylvania has several peculiarities of its own. In the first place, it is located in Philadelphia, a highly-significant fact, and one quite sufficient to give it unique rank among similar institutions. In the second place its faculty includes a number of practising architects, of whom the names of Messrs. Frank Miles Day and Wilson Eyre are alone sufficient to guarantee the progressive qualities of the School and give it an importance entirely its own. The greatest danger of professional schools, not architectural alone, but of all sorts, is fossilization. The professor, busily engaged in teaching the elements of his profession, is apt to forget the real progress he can learn only by keeping constantly and closely in touch with it. The Philadelphia School, it will be noted, entirely removes the possibility of stagnation by associating active architects of the first rank in its management and teaching. And lastly, this School is extremely fortunate to have at its head Professor Warren P. Laird, who combines executive skill with artistic enthusiasm in an unusual degree. Placed at the head of an important school early in life this gentleman has shown himself entirely worthy of the confidence placed in him. Whatever the School of Architecture of the University of Pennsylvania is to-day is due entirely to the labors of Professor Laird; and fifty years hence the mark of his work will still be felt. The future of this School must be a matter of the first interest to all interested in architectural education in America. Though conducted on the usual French-American plan that appears indispensable in American schools of architecture, it gives evidence of a modern feeling that is suggestive of better things to come. We are glad to congratulate Professor Laird on the good work he is doing, and the people of Philadelphia on having the benefits of his services. The School of Architecture of the University of Pennsylvania is the only architectural school we know of in which 20 per cent. of its faculty is composed of Doctors of Medicine.

"A YOUNG ARCHITECT" calls our attention to the fact that, in cataloguing the methods of obtaining success in architecture, as we did recently, we neglected to omit what, we presume, may be called the genealogical or connective method. We acknowledge the omission, and hasten to correct it. This method is quite obvious, depending, as its name implies, upon the rich and influential connections a young man may have and from whom work may be obtained. It is a most important element in success, and, if the young architect is abundantly supplied with such desirable relatives and connections, he has only to inspire them with a sufficient respect for his abilities to obtain the very greatest of successes, without the smallest aid from a public voice or the slightest necessity for performing on his own trumpet. Every one will agree with this, and it helps to point the lesson we sought to bring out in our previous remarks on the subject, that architectural success is quite apart from architectural merit and that one may be the most utterly bad architect in the world and yet secure the greatest proportion of "jobs." Alas! that the refined soul of the artist-architect should stoop to the necessity of looking up "jobs." Alas! that the long-suffering public must stand for all time—for the bad work invariably lasts unconscionably—the results of such a system. Alas! for those inspired minds that can do good things—on paper—and never get an opportunity to show the world how much better they would look were they carried out as they conceived them than most of what is done. Alas! for the time that permits such things. Alas! for the lack of knowledge and appreciation that makes it an element in our current work. Alas! that opportunities for the workings of architectural geniuses should depend on such sordid conditions Alas! that so much good work is lost, and, alas! that so much that is bad is carried out. Alas! that the puller-in (of jobs) should go on his way rejoicing through life and the good man should die unknown and unappreciated. Alas! this is a veritable wilderness of architectural woe, and the time we live in, yes (alas!), almost our own country, is the most woeful vale of any time, of any land, of any race. Alas! oh alas! for a voice with which to wail over the dull, dreary, disconsolate, distorted conditions of our architecture. Alas! alas! alas!

A COMMITTEE of the Architectural League has drawn up a series of rules for the government of architectural exhibitions that must strike terror to the hearts of those slipshod architects who try to erect buildings without suitable drawings, or at least with the aid of drawings that are not showable. The number of these gentlemen is increasing with lamentable rapidity, and both architectural publishers and exhibition committees are loud in their complaints of the difficulties of obtaining suitable drawings. If the rules proposed by the League's committee are carried out this difficulty will be remedied in the most thorough manner. Briefly, these rules require that all perspectives must be accompanied with plans; that a large-scale drawing or detail of some one portion of the building shall accompany each exhibit; that the object of the exhibition shall be to exhibit a complete representation of each building rather than a greater number incomplete in essential details. With these suggestions go the further recommendation that sufficient notice be given prior to the holding of an exhibition of architectural drawing to enable proper preparation to be made for it. With the exception of very young men whose genius has not yet received the recognition it deserves, it is doubtful if any practising architect has the time necessary to make the desired preparations for exhibitions contained in these suggestions. That they are good in themselves goes without saying; that they are directly in the line of progress and of art is likewise incontrovertible; that architectural exhibitions would be raised to a sorely needed standard were they carried into effect is unquestionable; but with all this it may be asked if the standard set is not too high to meet actual conditions; if more is not asked for than individual architects may be disposed to give for the benefit of their professional brothers; if it is not the ideal that is set forth rather than the practical. It would scarcely seem advisable to set up an ideal standard in this busy practical unideal world that will not take into account its unideality and horrible practicability. The architectural standards of architectural exhibitions sadly need elevation and improvement, but it is doubtful if this happy end will be brought about by insisting on conditions that will close these collections to the larger body of architects. The suggestions of the committee are, however, entitled to the most exhaustive consideration, and are very decided evidence of the earnestness with which some architects view their professional responsibility.

THE insistance on the plan as secondary to the elevation, which is one of the cardinal principles of the École men, is a position in architecture that we must confess we do not understand. The importance of the plan is a matter on which there can be no dispute. But a good plan is very far from implying a good exterior; nor does a good exterior imply a good plan. That it should need not be argued; all we are concerned with is that it does not. The plan is the part of the structure we live in; it is the thing that determines the value of the building and is itself determined by its function. But no thoughtful architect should rest satisfied with a plan, be it ever so fine. The most perfect and splendid plan in the world is utterly useless in itself until the walls have been built and roofs put on. Indeed, if we look at the question from this standpoint, the plan becomes somewhat insignificant, since it is possible to live within walls and under roofs with the most unartistic plan in the world. The vertical elements of the building cannot, therefore, be referred to unimportant places in the whole conception, and any system that ignores the elevation in order to put more thought upon the plan is deliberately ignoring a fundamental part of architecture. Students at the École des Beaux-Arts think it no unusual thing to devote almost all their time, in working up a problem, to the plan, leaving the elevation to the last few days, a system that thoroughly accounts for the inferior nature of many École elevations. It is not a misfortune that the elevation is simply the part of the building we see, while the plan is the part we live in. It should be as much the duty of the architect to line the streets of our cities with structures pleasing to look upon, satisfying, artistic, perhaps beautiful, as that he should arrange their interiors to present a monumental aspect when possible, to show good domestic arrangements, when the structure is of that class, to arrange for rapid and ready mode of ingress and egress when these are the most important elements to be taken into account. No one will contend that the elevation should be slighted, but when it is placed secondary to the plan it is sometimes very easy to do so. Let us have good plans, if we can—artistic ones if possible—but let us have fine and satisfying exteriors with them.

THE working library of the modern architect includes a variety of industrial publications, which business competition and the desire to please have long since made costly books. Perhaps no series of the industrial catalogues the architect is called upon to consult are now more costly than those issued by hardware firms. Covering all branches of the trade, they still include a vast amount of information useful to the architect, who cannot well afford to be without representative publications of this class. Among the more important of these catalogues that have recently come to us special mention may be made of that issued by the Lee-Clarke-Andreesen Hardware Co., of Omaha. It is a ponderous quarto of 1012 pages, abundantly and handsomely illustrated, and covering the entire range of the hardware industry. The subjects are arranged under heads and the architect and builder will lose no time in finding their specialties.——The catalogue of the W. Bingham Co., of Cleveland, is a valuable and interesting book of 1476 pages, illustrated with nearly 7000 engravings. The page is a small octavo, and for convenience in handling it has manifest superiority over the older style of quarto catalogues. The list of subjects catalogued is wide, the arrangement good, and the whole work a model of its kind.——P. & F. Corbin, of New Britain and New York, send us a portfolio of "fine builders' hardware." It is printed in good style and purports to illustrate the more expensive grade of door-hinges, knobs, and the like. Some of these, however, are of an aggressive and obtrusive design that cannot be commended for good taste. We imagine, however, that they fill a well-tested demand, and therefore enjoy a popularity of their own.——The Ludlow-Saylor Wire Co., of St. Louis, send us a large illustrated catalogue of the metal-work made by them,—chiefly railings, elevator-enclosures, gateways, iron fencing, and the like. Many of the designs are very striking and good, and a large number are of sufficient grace and beauty, without over-elaboration, to render them very acceptable.——The Heckla Iron Works, of New York, send us a couple of illustrated catalogues, representing their work in a very thorough and convenient manner.

MINING AND METALLURGY

Conducted by Albert Williams. Jr.

A MOST important ruling, which will directly affect many mining titles, has been rendered by the United States supreme court in the Amy–Silversmith case. In this instance the course of the vein had carried it, not through the end lines, as presumed by the locator, but across the side lines, and the owner in following the deposit down on the dip had worked beyond the vertical plane of a side line into adjoining property. Suit was brought to recover value of ore extracted from the disputed ground and the case was finally carried up to the supreme court. In similar cases, which have been numerous, the lower courts have usually held that the end line should be drawn back to the point where the apex crosses a side line, and the mooted point has been, not whether the locator was entitled to take ore from beyond his side line, in following the vein down, but to what extent, the discrepancies in the rulings having been as to whether the amended end lines should be drawn at right angles to the strike or at right angles to the side lines. As is generally known, the United States mining-law permits working beyond the vertical projection of the side lines and prohibits working beyond the vertical planes of the end lines; also that the side lines must be parallel to each other in every part, though not necessarily straight, and that the end lines must be parallel to each other. This latest decision, which overrules all former ones and will be the established precedent for the future, holds that what were called side lines are in fact end lines; hence, that the owner cannot go beyond them. It also holds that it is not the duty of the court to relocate for an owner who has made a mistake in laying off his claim, and do for him what he should have done for himself; in short, that he must abide by his error, and that all that the court can do is to secure him in the possession of that ground to which he is entitled on the narrowest construction. The ruling is very clear and positive. It will no doubt work hardship in many cases yet to be tried, but it is the final say of the court of last appeal and must stand. It will be well for prospectors and mine-owners to seriously realize this, and use great care in staking off claims. As a matter of fact, it is often difficult to trace an apex through the whole length (1500 feet) of a claim and to make sure that it is contained within the width (300 feet on each side, according to the United States law, and much less according to some district regulations) at the ends. At the time the stakes are set the small amount of development work does not always determine the true course of the vein, as there may not be continuous croppings and the blind parts may be covered by heavy wash. Locators will have to exercise great care and judgment in fixing their surface boundaries. It has been suggested that this ruling will also affect a class of locations in which the apex is contained within one end line but not within the other, crossing a side line instead. Such cases are not uncommon. Evidently the decision, while finally clearing up a perplexing point, opens the gates to a new tide of litigation, the result of our complicated laws, already so injurious and deplorable.

The long-continued strike of the miners in the Cripple Creek (Colorado) gold-camp was for eight hours' work, instead of nine (previously the custom in that district), and to receive $3 a shift, the wages formerly paid for a nine-hour shift. Plenty of men were willing to accept the old terms or the proposed compromise of 33⅓ cents an hour, but when the companies tried to start up again on the former basis, intimidation was resorted to by the strikers. The sheriff, being unable to protect the working miners and the companies' property, called upon the governor to order out the militia. The militia, after a brief demonstration, but accomplishing nothing, were retired by order of the governor. In this case, as in so many others, the strikers had a clearly hopeless chance from the start. The mine-owners could afford to close down and wait, but the men could not. As a question of policy, to say nothing of right or wrong, the strikers placed themselves in a false position by threats and actions. Nobody denies a man's right to refuse to work on terms that do not suit him; but the other man, who is willing to accept such terms, has an equal right to do so, and should be protected. The trouble at Cripple Creek involved a deeper issue than a small dispute about time and wages; it brought out anew the underlying principle of inherent rights, and the public, understanding the situation, has withheld sympathy from the strikers. There is no prejudice against miners' unions as such, so long as they keep within reasonable purposes and do not infringe upon common justice. They can do much good in their proper sphere, but too often do harm; and the injury almost always falls upon their members in the end. In this latest instance, as has so often happened, the agitation seems to have been stirred up by a few wrong-headed leaders, and was not the result of unanimous feeling; though the men, regarding it as a test of union strength, stood by their colors whatever their individual judgment may have been as to the merits of the struggle.

In designing mining or metallurgical plant, the element which corresponds to the factor of safety (or, rather, of uncertainty) in civil and mechanical engineering is necessarily a large one, from the nature of the conditions, which are various and uncertain. An extra margin of strength is always advisable, and where the additional weight is a drawback in transportation from the foundry or machine-shop to the site of the works, it is customary to resort to sectional construction. Great ingenuity has been bestowed in producing composite machines and appliances, the object being to avoid sacrifice of stability while making the parts easily transportable. The limit of weight in single parts, for use in Spanish American countries and in the less accessible portions of the United States, is from 250 to 300 pounds, or the weight that can be "packed" by mule.

Similiar to this allowance for extra strength (whether provided in the usual forms of construction or in built-up machines) is the extra margin of power allowed, to insure regularity and reliability, which are more essential in mining and most metallurgical plant than in factories nearer the base of supplies and more readily remodeled. It is important that all allowances should be made at the right end; that is, at the beginning. Thus the boiler rating should not only be above the nominal engine-rating (which is sometimes only about half the indicated horse-power), but with a fair surplus above all expected demands, as it is often necessary to add small auxiliary motors, feed- and fire-pumps, etc., not counted in the first calculations and for which small separate boilers would be inconvenient. This rule applies to all powers, as well as to steam. In mining it is not always certain what maximum loads may have to be handled, so the engine in its turn should have a surplus power above normal requirements.

The same principle holds in many other directions. For example, it is always prudent to select sites and design foundations and housing with a certain excess, to allow for future enlargements, or, for a last example, though many more might be quoted, take the question of water supply for an amalgamation or concentration or combination mill. Turning to the catalogue of a leading machine-shop, we find, after the estimate of 7½ gallons per horse-power per hour, the following requirements stated: for each stamp, 72 gallons; for each pan, 120 gallons; for each settler, 60 gallons; for each belt vanner, about 90 gallons of fresh water per hour, and there are like proportions for other machines and apparatus. But it would not do to figure on a water-supply that would only just come up to the total of these items, even allowing for pumping back and re-using (at a loss of 25 to 33⅓ per cent.) the water from settling ponds, for certain restricted uses. Each item should be considered as a minimum, and a very ample allowance must be made in the total supply to cover inevitable loss by leakage and evaporation, and to meet the many demands not specified. It is true that there are records of 10-stamp mills being run on 700 gallons per hour, but such figures must be accepted guardedly. The general principle is that a very liberal margin must be provided to start with, both in power and everything else, and the original plant, may then, as it were, taper down toward the last machine or use. It is easy enough to add on at the lower end.

THE latest estimate of the amount of royalties on coal- and metal-mining in Great Britain at hand is for 1889, when the figure was put at about £5,000,000. There are no statistics or estimates regarding similar royalties (paid, however, to owners of the land, not to the government) in the United States or for any considerable part of them. But the total amount must be very large, considering the great numbers of coal and iron mines, besides some others (as phosphate mines, for instance), that are operated on this plan. In the far west also there are the "leasing" and "tribute" systems of working mines of the precious metals and their accessories, and in the aggregate the amount thus paid by operators to owners must be considerable. A royalty (as the word itself indicates, in its original sense) in many or most foreign countries usually means the percentage paid to the crown, which under old laws never relinquishes the theory of inherent ownership to mineral lands.

THE Chicago exponent of the coal trade, *Black Diamond*, speaking of a newly-invented and much-lauded electric coal-mine lamp, after noting that the crowning merit of the lamp, according to the reports, is that "it has been repeatedly broken in gases much more explosive than fire-damp, without an explosion, very sensibly remarks that "it will be more satisfactory to test the fact in our [coal] mines and find out for ourselves the virtues of this lamp before believing in them." It is difficult to understand how the act of breaking can so instantly extinguish the lamp by any device for shutting off the current as to remove all danger. Even after the current has ceased the filament continues to glow for an appreciable time, and at a temperature sufficiently high for ignition. This has been the great obstacle in all electric light safety lamps, and it would seem a simpler, more rational plan to design them with a view to preventing breakage rather than to endeavor to make them safe in that event. Still, it is possible that the feat has been accomplished, like so many other unlooked for things, and thus it is premature to hazard an adverse criticism, though, with *Black Diamond*, we should like to see it done.

CRUSHING-ROLLS of an entirely new type have recently been introduced. Their novelty, as compared with the plain Cornish rolls and the many modifications from the latter, consists in the peculiar construction and arrangement of the crushing faces, which, instead of being plain cylindrical shells, have a series of deep parallel corrugations extending across the shells, either parallel or inclined to their axes. These corrugations are rounded or curved with such proportions that they intermesh, the idea being to cause every portion of the surface to press equally upon the counterpart of the opposite roller. The rolls are held in position by steel gear, slipping of the faces upon each other or the material to be crushed being claimed to be impossible. Rolls of this type should crush with little grinding, and by avoiding the making of slimes should give a satisfactory product for sampling, concentration, and lixiviation — which is one of the best features of all roller crushers. Without knowing how the new rolls stand long usage, it would seem that the disadvantages most likely to be expected would be the difficulty of keeping the faces true, additional danger of breakage of gears in case of overstrain should an obstruction like a hammer-head or other tool drop in, and a more expensive shape to produce. But the principle evidently has its merits.

ANOTHER "new" patented process for rapidly chlorinating gold under pressure, and for rapid filtering of the pulp, has a familiar appearance in its published description. In the main it is said to consist in generating the chlorin in the chlorinating vessel, the gas making its own pressure. The special patent on the filtration seems to depend on the use of charcoal, by which the gold is reduced to the metallic state and is precipitated on and in the filter. Both ideas are sound, but are by no means novel, having been proposed, experimented upon, and used in practice years ago.

AN advance statement of the total mineral production of the United States in 1893, to be published in the forthcoming volume of the "Mineral Industry," gives the following figures, which, though still subject to revision, are claimed to be very nearly accurate:

Asbestos, short tons	120
Antimony ore, short tons	850
Asphaltum and asphalt rock, short tons	34,944
Barytes (crude), short tons	26,632
Bauxite, short tons	11,041
Borax, pounds	8,690,000
Bromine, pounds	348,399
Cement (hydraulic), barrels	7,503,385
Cement (Portland), barrels	596,531
Coal, anthracite, long tons	48,044,834
Coal, bituminous, long [?] tons	113,847,568
Coke, short tons	9,792,330
Cobalt oxid, pounds	3,893
Copperas, short tons	16,000
Corundum, short tons	1,747
Chrome ore, long tons	1,629
Feldspar, long tons	17,000
Flint, long tons	38,000
Fluorspar, short tons	9,700
Grindstones, short tons	45,580
Infusorial earth and tripoli, short tons	1,709
Limestone, for iron flux, long tons	4,551,000
Magnesite, short tons	1,143
Manganese ore, long tons	9,150
Marl, short tons	110,000
Mica, pounds	75,000
Onyx, cubic feet	2,175
Ozocerite (refined), pounds	none.
Petroleum, barrels	50,349,228
Phosphate rock, long tons	983,340
Plumbago (refined), pounds	896,603
Plumbago (crude), short tons	1,500
Pyrites, long tons	95,000
Salt, barrels	11,435,187
Slate (for roofing), squares	871,500
Soapstone, short tons	20,100
Soda (natural), short tons	2,500
Sulphur, short tons	1,344
Talc (fibrous), short tons	36,500
Venetian red, short tons	3,830

METALLIC PRODUCTS:

Antimony, short tons	350
Copper, pounds	322,585,500
Gold, troy ounces	1,731,700
Pig-iron, long tons	7,043,384
Lead, short tons	193,928
Nickel, pounds	25,898
Quicksilver, flasks (76½ pounds)	30,161
Silver, troy ounces	60,500,000
Spiegeleisen and ferro-manganese, long tons	81,118
Tin, pounds	none.
Zinc, short tons	73,355

Most of the items show a decrease in production as compared with the output in 1892, the decline having mostly occurred in the latter half of 1893, after the midsummer financial crisis. Still the list makes an impressive showing.

THE notes in this Department on inclines versus vertical shafts have elicited considerable correspondence on the question. Among others, Mr. W. D. Brunton, general-manager of the Della S. Consolidated silver-mines and Cowenhoven tunnel at Aspen, writes that the solution of the problem in the case of that property has been extremely satisfactory. He gives the following account of the method pursued:

Two years ago the writer was brought face to face with the problem of shaft versus incline in a mine where the conditions were more than ordinarily complicated. Work had to be commenced upon an ore body pitching at an angle of 56° from the horizontal, which had been intersected by the Cowenhoven tunnel, nearly three-quarters of a mile from its mouth and 1000 feet vertically below the surface. It was out of the question to drift through the ore body into the hanging wall so as to intersect the vein with a vertical shaft at any reasonable depth, as the shales which overlaid the ore had an unfortunate habit of "creeping" in and crushing timbers faster than any company could afford to renew them. Directly underneath the ore body, and separated from it by about 80 feet of dolomite, was an open porous stratum of silicious dolomite threaded with a network of water courses. If a vertical shaft were sunk from the point where the ore body was intersected by the tunnel, it would pass directly through this water-bearing stratum, which would also be intersected by every cross-cut from the shaft to the ore bodies on their continuation below.

Inclines, as every miner knows, are unhandy, expensive, and dangerous, and an existing 750-foot incline on the same property had proved itself such an unfailing source of worry to the manager and expense to the company that the prospect of a second incline was as much dreaded as a flooded shaft. One day, while I was studying the question, the following idea suggested itself. "If a shaft, after having been properly sunk and timbered, should be thrown out of the perpendicular by some movement of the earth's crust, would it cease to be shaft because it was no longer plumb, and if it was tilted over on its end instead of its side would there be any reason why the cars could not be run directly from the cages into the drifts without interfering in any way with the pump compartment or man-way?" Never was an idea more eagerly welcomed or acted upon with greater good will by all concerned. The miners who began work on the shaft, especially the old-timers, who are naturally conservative, looked with some suspicion upon this plan, but before a week had elapsed they arrived at the unanimous conclusion that an inclined shaft was easier to sink, safer to work in, and more convenient to operate than a vertical shaft, and that the old-fashioned incline should hereafter be considered a thing of the past.

This inclined shaft has now been sunk to a depth of 250 feet in the face of a very heavy flux of water, in extremely difficult ground, and so far without a single accident. At 84-foot intervals levels are run out from the shaft each way, down to which the tunnel cars are lowered on a cage, beneath which is attached a light steel self-dumping skip for the use of the men who are sinking, and the operation of drifting, mining and sinking go on simultaneously without in the least interfering with each other.

The incline spoken of is two-compartment and has its longer axis of cross-section at right angles to the dip instead of parallel with it as more usual. The pump-compartment is above the hoisting compartment. It is locally called an "inclined shaft" rather than an "inclined winze" because, as Mr. Brunton explains, "ordinarily we speak of a winze as an underground connection between two levels, but the main opening from which these levels are driven should be designated as a shaft or incline no matter whether it terminates on the surface or at a station a thousand feet below." The hoisting machinery is situated in a large station cut out of the solid rock on the level of the Cowenhoven tunnel. There is no intention of connecting this incline shaft with the surface, as there could be no possible gain by such a proceeding. The machinery is at present operated by compressed air, but an entire electrical equipment, including hoist, pump-winch and pumps has already been ordered. The "cage" runs on wheels, but is altogether different from the Comstock giraffe.

ALUMINUM-BRONZE, nine parts copper to one of aluminum, has a very high tensile strength, and it is said that the alloy can be produced in castings for about the same cost as crucible steel. It has been suggested that its use might be extended to replace steel for many more purposes than is now done, as the castings can be made very true to pattern, thus saving part of the expense of working to shape. For certain uses, as in replacing ornamental ironwork, its golden color recommends it as improving the artistic effect.

IN most of the foreign countries and the states of the Union which have mining laws at all, it is required that each mine must have two exits, but the rule is very commonly evaded or ignored. A recent fire in a California gold-mine has sharply directed attention anew to the urgent necessity of providing means of escape to miners who may be shut off from the main shaft or other principal opening in case of fire or caving; and old air-shafts are being repaired and made feasible for egress. The substitution of iron ladders, not subject to decay, in place of wooden ones has been recommended and adopted as a further precaution.

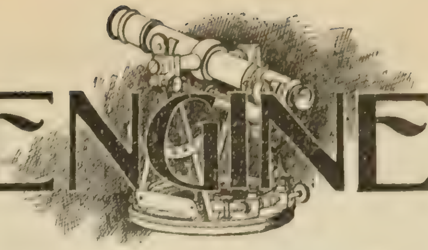
THE spelter (zinc) production of the United States in 1893, as compiled by Mr. Charles Kirchhoff, Jr., agent for the division of mining statistics of the geological survey, was: Eastern and southern states, 12,684 tons (2000 pounds); Illinois, 29,596 tons; Kansas, 22,815 tons; Missouri, 13,737 tons; total, 78,832 tons, against 87,160 tons in 1892. The decline in the output took place wholly in the second half of the year. The production of zinc oxid is estimated at 24,059 tons, of which 14,954 net tons was produced in the eastern district, as compared with 19,129 tons in 1892, and 9150 was made in the west in 1893, as compared with an estimate of 7700 tons in 1892.

VENTILATION by an electric-driven fan has recently been tested in a German colliery. The workings having been much extended, it was found necessary to sink an air shaft two miles distant from the old shafts. A Capell fan was then put in, with a double 10-foot inlet, operated direct by two slow-speed electric motors, one on each side of the fan, one being held in reserve. The results were as follows: electric horse power of dynamo, 47; electric horse-power on fan-motor two miles off, 43; indication of engine, 64 horse-power; revolutions of fan and motor per minute, 197; water gage, 2.4″; cubic feet of air per minute, 88,500; useful effect of fan, 74.4 per cent.; useful effect of plant, 54 per cent.; voltage, 1000.

ONE of the text-books informs us that the legal definition of a mine includes only "such workings as must be artificially lighted." But why did not the legal luminary from which this ray of wisdom shone turn on a little more candle-power, if it was intended to make everything perfectly plain, and specify further that this artificial lighting should be required only by day? Then there could be no doubt as to the exclusion of all the placer mines and open-cut mines. The laity who have been working such claims under the mistaken impression that they were really mining would like to be sure whether they were or were not doing so, and to settle this serious question the interpreter of the law should be more explicit. As it stands, this definition is about as precise, though hardly as graphic, as the one often used in a derogatory sense, when speaking of a dubious prospect—"a hole in the ground."

CANNEL coal, claimed to be the best of the kind yet found in the west, has been discovered at Vermont station, Missouri. The bed is reported as ten feet thick. Coal of this character commands high prices for domestic use and is often transported over long distances throughout the areas where it is not produced.

CIVIL ENGINEERING



By John C. Trautwine, Jr.

THE importance of the government tests upon full-sized timbers, which have been in progress for several years under the direction of Professor J. B. Johnson, coöperating with Mr. B. E. Fernow, chief of the division of forestry, department of agriculture, is so generally recognized by engineers that Professor Johnson's circular calling upon those interested to memorialize their representatives in congress in behalf of the work, is sure to meet with generous support. The favorable expressions of opinion already made by the engineers of the country, have resulted in obtaining from congress appropriations which have already permitted the accomplishment of a vast amount of useful work, but far more money is needed in order to do justice to the subject, and it is particularly desired that an additional testing laboratory should be established on the Pacific coast, in order that our knowledge of the valuable timbers of that region may be increased. Senators Roach and Proctor are a subcommittee of the committee on agriculture and forestry having in charge a bill appropriating further moneys for the prosecution of this work, and it is earnestly to be hoped that our engineers, who, even more than the rest of the country, have much to gain from these investigations, will make themselves heard in support of the measure.

As might have been expected, the Benevolent Fund of the Institution of Civil Engineers of London has, like other organizations, felt the pressure of the hard times. Indeed, it has found itself between the upper and the nether millstone, the subscriptions falling off, and the demands upon its services very naturally increasing, so that it has been found necessary to trench upon the reserve account. The income proper during 1892 amounted to about $15,000, of which $7000 were derived from annual subscribers, while the grants made amounted to $20,000, leaving a balance of $5000 upon the wrong side of the account. The total cost of working the fund for the year was about $600, a fact which implies that a great deal of gratuitous labor is done in connection with the work of the fund. The falling-off of subscribers has resulted in a showing that only 13 per cent. of the total number of 5618 members of the Institution are contributors to the Fund, which is a voluntary association established to render assistance to necessitous members of the Institution or to their families.

In a previous number of THE ENGINEERING MAGAZINE we recorded the death of M. Paul Jousselin, president of the French Society of Civil Engineers. His loss was shortly followed by that of Mr. Charles Herscher, the vice-president of this society, who was taken ill while attending a meeting of the chamber of commerce in January, and who died on the following day. Mr. Herscher had been a member of the society since 1872. During 1893 the society also lost by death M. V. Contamin, one of its past presidents, a man widely known for his scientific attainments.

In the March number of THE ENGINEERING MAGAZINE brief reference was made to the installation of the hydraulic power-plant of the Niagara Falls Paper Co. by R. D. Wood & Co., of Philadelphia. At a recent meeting of the Engineers' Club of that city Mr. Emile Geyelin, the designer of the plant, presented a paper illustrated with lantern-slides and with a large-scale diagram, describing this important and in some respects, novel work. The turbines, of which there are three, and which operate under a head of 140 feet, take their supply of water from the race of the Cataract Construction Co., while their waste water is discharged into its tail-race. The water descends from the fore-bay of the turbines through a cylindrical penstock of iron plates and 13′ 6″ in diameter.

As already remarked, the turbines, which are the first hydraulic motors discharging into the great tunnel, are of the inverted pattern, the water entering them from below, so that its pressure counter-balances the weight of the turbines with their gearing and the long vertical shafting by which their power is transmitted to the ground level; and so accurately is this balance accomplished that it is found that when the wheels are running at full gate there is a slight upward pressure on the thrust-bearings, and a slight downward one when they are running at part gate. Indeed it is found that a man, by inserting his finger between the top of the vertical shaft and the horizontal shaft which revolves just above it, can detect the difference in pressure due to the difference in the amount of power employed. The velocity in the penstock, when the wheels are running full, is a little over two feet per second. The three vertical shafts are stayed, at six points between their ends, by horizontal frames of I-beams, while at the top and bottom cast-iron beams are used for the bearings of the turbines and of the gearing by which the power is transmitted. During the discussion Mr. Geyelin explained, in reply to a question, that the object in using cast-iron at these two points was to secure a greater rigidity than could have been obtained by the use of wrought-iron.

As is well known, the falls of Niagara, while much the most stupendous and celebrated, are by no means the only great water-falls in that remarkable region of horizontal strata which occupies western New York. The Genesee presents a remarkable series of falls at different points in its course. Perhaps, from the very reason that they are of less height than their great western competitor, their power seems to have received, up to this time, more complete development. Mr. Cartwright, to whom we have already referred, has recently completed a water-power installation for electric light and power, at Rochester, N. Y., and at the March meeting of the American Society of Civil Engineers he presented a very interesting and instructive description of the work. The fall is of course very much less than that at Niagara, being only feet, and the arrangements are necessarily widely different in other respects from those employed at Niagara. Here the turbines, instead of the shafting, are vertical. During the course of this work Mr. Cartwright has had occasion to make exhaustive studies of the subject of rope-belting, one of the important results being, as might have been expected, that the formulæ for the effect of centrifugal force in reducing the friction of the belt, require complete modification on account of the friction obtained by the wedge-like action of the rope belts in their V-shaped grooves.

In view of the sudden and violent changes of power to which the system is subject, amounting to as much as 100 or 200 horse-power, Mr. Geyelin concluded that the employment of mortise-wheels was absolutely essential, and the blows to which the teeth would be subjected under these changes rendered the use of a hard and brittle material in the driven gears inadvisable and led to the employment of wood. This required the adoption of a large diameter for the wheels and the circumferential velocity of 4000 per minute, which is believed to exceed any heretofore adopted, the greatest on record, so far as could be ascertained, being about 2800 feet per minute.

One of the most serious obstructions to street traffic in Philadelphia is the existence of the main line of the Philadelphia and Reading railroad, crossing at grade a dozen or more important thoroughfares between Broad street and Fairmount park. As the crossings are protected by gates, the danger from passenger-trains is perhaps a less serious matter than the frequent delays arising from the drilling of long freight-trains. Arrangements have now been made for concerted action between the city authorities and the railroad company by which the tracks of the latter will be depressed and the city streets will be carried over them by bridges.

FOR a year or two past, Professor E. A. Fuertes, of Cornell University, assisted by Mr. Rudolph Hering and Mr. James H. Fuertes, has been engaged in an investigation of the sanitary conditions of the seaport town of Santos, in the state of São Paulo, Brazil, and they have recently issued a most elaborate report upon the subject, constituting a volume of 146 pages, besides as many more of specifications. The town of Santos, with a population estimated at about 27,000, is situated upon an island lying about three miles back from the Atlantic coast, some 300 miles west-southwest of Rio de Janeiro. The island is a low, marshy plain, crossed by a range of the granitic foot-hills of the Serra do Mar, or Coast Range. The town has been subject to visitations of the smallpox and other scourges, and, while in some years no yellow fever deaths are reported, there were 1676 deaths from that disease in six months of 1892, giving a rate of 124 deaths per 1000 inhabitants per annum.

The locality was examined by Mr. W. Milnor Roberts in 1881, and this examination, as well as that by Professor Fuertes and his associates, developed a condition of things quite sufficient to account for a high degree of unhealthfulness. There is no efficient quarantine; the water-supply, which is from the hills, comes through pipes of inadequate size, and no proper system of sewerage has been inaugurated. Prior to 1889 the sewage of the town was discharged into the drains and brooks which convey the rain-water from the hills to the harbor, some of which were covered with flat stones, while others discharged through badly-jointed clay pipes, of insufficient slope and capacity, some of them passing under the basements of houses, of course polluting the soil around them. In the year named a contract was entered into for the construction of a sewerage system, which contemplated, among other things, arrangements for sewage-purification, but the system appears never to have been put into operation, and what has been completed of it is very defective, so that the city is still dependent upon the old drains. The intended purification of the sewage, if it was ever practised, has been abandoned. The dead are buried in ground saturated with water. The harbor is overcrowded, but dock improvements which are in progress promise to remedy this difficulty.

The engineers, in the course of their studies of this problem, have visited not only the site in question but many works of sanitation in England, France, Switzerland, and Italy. Their report, which opens with something like a treatise upon sanitation in general, recommends the establishment of a rigorous and efficient quarantine system, an improvement of the water-supply by the substitution of larger mains and distribution-pipes, and the possible addition of other sources of supply, the enforcement of regulations against food-adulteration, the substitution of cremation for burial, improved dwellings for the inhabitants, the removal of garbage, the paving and cleansing of the streets, the drainage of the plain, and the proper sewerage of the city.

The report advises against the artificial purification of the sewage, on account of its expense and of the ample means at hand for proper dilution. The separate system is recommended, with an outfall into deep, swiftly-running water. For one of the three districts into which the town is divided, a district in which it would be impracticable to deliver the sewage by gravity to a point where the pumping-station would be economically available for the other two districts, the Shone ejector system, which has been used in Rangoon, India, at the World's Fair, in the houses of parliament, and in many European and American cities, is recommended.

OUR esteemed contemporary, the *Engineering News*, has introduced into its extremely simple pile formula—

$$L = \frac{2\,w\,h}{s + 1}$$

where L = the safe load on a pile,
w = the weight of the ram,
h = the height of fall, in feet,
s = the penetration per blow, in inches,

a modification intended to adapt it for use in cases where the piles are driven with the steam-hammer or with the gunpowder pile-driver. The modification for the Nasmyth steam-hammer consists in substituting for unity in the divisor the quantity 0. 1, while for the gunpowder driver the coefficient 2 in the numerator becomes 4. The steam-hammer allows only from one-tenth to one-twentieth as great an interval of time between blows as does the ordinary pile-driver, for which the fundamental formula was constructed. Hence, it is argued, the resistance to penetration under the blows, which depends largely upon the time allowed the surrounding material to compact itself, will be but about one-tenth as great, other things being equal, and the factor 1, which, it is claimed, covers these resistances, should therefore be made but one-tenth as great. The gunpowder-driver is similar in its action to the ordinary machine, and the interval between its blows is also approximately the same. Hence the divisor is not changed, but, inasmuch as the force of each blow is contributed not only by the actual fall of the ram, but also (and to an equal extent) by the expansive energy of the powder, which drives the ram up again for the next blow, the coefficient in the numerator should be doubled.

In support of its formula the *News* cites at considerable length an admirable case described in its issue of July 6, 1893, admirable in all but this, that, owing to the desirability of getting on with the work of construction, the loading of the trial piles was most unfortunately stopped somewhere short of the point which would have caused settlement, how far short nobody knows, so that after all the pains taken with this test, it falls lamentably short of its full measure of usefulness.

AT the Old Point convention of the American Society of Civil Engineers, in 1892, the writer submitted a complete list of all the cases he could by diligent search bring to light, in which the four all-important items, weight of ram, height of fall, depth of penetration, and *extreme* load, were given. These results were painfully few in number, and many of them were still more painfully deficient in accuracy and reliability, yet they formed what appeared to be the entire available stock-in-trade of useful data on the subject, and they showed, if they showed anything, that even the two formulæ which, of those examined, made the least forlorn attempt at fitting them, were lamentably at sea, that elaborate arguments upon *a priori* methods are hardly worth the trouble they take, and that close coincidence of any formula with one or more cases really amounts to but little.

AS pointed out at that time, the great difficulty in the use of formulæ for ascertaining the proper loads on pile-foundations lies in the smallness of the penetration and in the difficulty of ascertaining it with anything like sufficient accuracy. This factor is an indispensable one in any rational pile formula, yet it is usually of but small amount, and, from the nature of the case, it is seldom closely determinable, and yet a very small variation in this factor may profoundly affect the result obtained by the formulæ, and it is probably owing to this, as much as to any other fact, that we find such wide and discouraging discrepancies between the best of the formulæ on the one hand and the experimental results thus far obtained on the other.

THE avowedly partisan attack, led by Congressman Enloe, of Tennessee, upon the United States coast and geodetic survey, which institution he seeks to abolish, distributing its duties among other bureaus and departments, is calling forth vigorous protests from the engineering press and from technical societies. The survey is probably as well prepared for a congressional investigation as is any other branch of the government service, but, unless there are better reasons for its abolition than those brought forth by Mr. Enloe, the country can well afford to tolerate its existence for a while longer.

AN old and valued assistant in the survey, Captain Spencer C. McCorkle, was gathered unto his fathers in March last. To those who had the good fortune to know Captain McCorkle, his death will be a personal loss, for by his kindly courtesy he endeared himself to all with whom he came in contact and from whom his exceeding modesty did not hold him at too great a distance. During the latter years of his life he was particularly interested in the project for developing a line of what he called land-locked navigation for small vessels through the almost continuous line of bays and inlets which line the Atlantic coast from Sandy Hook to Florida, and the Gulf coast to the mouth of the Mississippi. Captain McCorkle urged the great value of such a means of communication in times of peace and its paramount importance in the event of war. He showed also that it could be called into existence by the expenditure of sums ridiculously small in comparison with the benefits which such a system would confer.

HARDLY have the echoes of the failure of the East Providence stand-pipe died out of the technical press when we have reported the collapse of that at Peoria, Ill., accompanied with the loss of one life and the injury of many persons. The pipe had been in use for about four years and had shown no signs of weakness, when, on the morning of March 30, it "burst with a succession of pistol-like reports." At the time of the failure the water was about 100 feet deep and amounted to about 400,000 gallons. Fragments of the plating were thrown to distances of 50 to 100 feet. The velocity of the wind blowing at the time of the failure is variously estimated at from six or eight to thirty miles per hour. It has been suggested by Professor William D. Pence that ice forming in the stand-pipe during cold weather may, by its expansion, have strained some of the rivet-holes, and that the water, entering these holes and freezing there, may have materially weakened some of the plates.

THE Q. & C. Co. has issued a photographic view of an oak tie protected by one of the company's Servis tie-plates. The tie in question was placed in the 78-foot grade on the Louisville company's bridge over the Ohio river in 1883. In 1889 it was ordered removed, on account of cutting by the rail-flanges, but, as the tie was otherwise still sound, the tie-plates were inserted and the tie allowed to remain. Since that time, it is claimed, no work has been done upon the track. Last year, although the tie, and others similarly protected, were found to be rotting away, the portions under the tie-plates remained sound.

M. EDMOND BARTISSOL, an engineer who was engaged upon the Suez canal, comes forward with a plan for the completion of the canal at Panama. His plan is a compromise between the sea-level project and that for a high level with lifts of from 122 to 175 feet, in that it contemplates a central level 75 feet above the sea, with but two pairs of locks at each end. In order to facilitate the removal of the great mass of material necessitated by this plan, particularly that in the world-renowned Culebra cut, M. Bartissol proposes to impound the waters of the upper Chagres and to bring them by an open channel to the side of the work, whence they would descend through a tunnel, with a grade of 1:1000, to the Pacific. This tunnel, according to M. Bartissol's plan, is to serve as a dump and a carrier for the excavated material.

The shareholders are reported as favoring the project, but the liquidators are inclined to regard it with distrust, arguing that while such a waste conduit might do very well for earth and gravel, it by no means follows that it will be equal to the task of disposing of the heterogeneous materials that may be expected to occur in the great cutting.

DURING the winter of 1873–74 the late and venerable Squire Whipple, honorary member of the American Society of Civil Engineers, erected, over the Erie canal at Hotel street, in Utica, N. Y., a lift-bridge of 60-feet span for the accommodation of the street traffic. The lift consisted of a movable platform, suspended from a fixed overhead truss, and raised and lowered by a man who operated a horizontal tread-wheel placed on the lower deck of the fixed bridge. Ten years later Mr.

William H. Searles, C. E., constructed a wooden lift-bridge of 27-feet span, to carry a railroad over the west branch of the Pennsylvania canal near Jersey Shore, Pa. The bridge was on a skew of 36°, and the trusses, if such they can be called, consisted each of two horizontal chords of 14 × 14-inch white pine, placed only 9 inches apart and separated by wooden blocks. The bridge was lifted and lowered by means of geared shafting, operated by means of a hand-crank. In this case the entire system was raised and lowered, and was not merely a platform as in Squire Whipple's bridge. About the same time a far more imposing structure of the same class was erected to carry the West Shore railway over the Oswego canal at Syracuse. Here the skew was 50° and the clear square span was 52 feet. As in Mr. Searles's bridge, the entire structure is raised and lowered, and, as in all such cases, the moving parts are counterpoised. The power required to overcome the friction is supplied by a small steam-engine placed at the center of the upper deck of the bridge.

THE three structures already mentioned required of course only such moderate lifts as adapted them to their work as canal-crossings, but Mr. J. A. L. Waddell has just erected over the Chicago river, at Halsted street, Chicago, a lift-bridge of 130-feet span, with a lift of 155 feet, through which the bridge can be raised or lowered in less than one minute. Here, as in the other cases, the lift principle was adopted because the narrowness of the channel forbade the construction of a draw-pier in the canal. On each side of the canal is built a steel tower 200 feet high and forming at its base a rectangle about 30 feet square. Of the four legs of each of these towers the two next the canal are vertical, while the other two are battered. The two towers are braced together, at top, by a shallow fixed truss, and between their vertical posts moves the lift, which consists of two trusses spaced 40 feet between centers and carries two lines of street railway track and two footways which are carried outside of the trusses.

The lift is suspended by thirty-two steel cables, which pass over four sheaves on top of each tower and are attached to counterweights which equilibrate the 300 tons weight of the bridge. From the lower side of the lift hang iron chains which are attached, at their other ends, to the counterweights, and which serve to counterpoise the excess of weight of the ascending over the descending ropes, or *vice versa*. The lift is operated by steam-engines placed below the street-level and operating upon it by means of eight 7-8-inch steel ropes attached respectively to the lift and to the counterweights. Underneath the bridge-floor are tanks filled with water, for adjusting if necessary the balance between the lift and the counterweights. The engines working the lift are controlled by a man who occupies a watch-box placed at the middle of the upper deck of the bridge. This box is provided with a "peeper," by means of which the attendant can tell when the lift has risen sufficiently to clear the masts of an approaching vessel, and he is thus enabled to avoid lifting the bridge higher than is necessary. The admission of steam to the cylinders of the lifting-engines is automatically cut off as the lift approaches the top or bottom of its run, and it is then gradually brought to rest by means of hydraulic buffers. The two vertical legs of each tower rest upon pneumatic foundations, while the battered legs rest upon piles, their feet being provided with means for adjustment in case the frames should get out of true.

DR. CHARLES B. DUDLEY, in charge of the department of chemical and physical tests of the Pennsylvania railroad, at Altoona, Pa., has issued, as chairman of the subcommittee on methods of the committee on international standards for the analysis of iron and steel, appointed by the World's Congress of Chemists, a bulletin addressed to those chemists who are engaged in the analysis of iron and steel, urging them to coöperate in the work of the subcommittee by forwarding replies to a series of questions touching matters connected with such analysis upon which general expression is desirable.

MECHANICAL ENGINEERING

Conducted by Henry Harrison Suplee.

THERE has been much foolish matter published in some of the newspapers about the alleged stealing of English designs in marine practice, the statement being made especially that the design of the boilers of the torpedo-catcher *Havock* was being eagerly sought and had actually been stolen by American spies. When it is considered that the construction, not only of these boilers but also of the newer water-tube boilers of the *Hornet*, was fully described two months ago at the meeting of the Institution of Naval Architects by Mr. Yarrow, by whose firm the boilers were built, the absurdity of the insinuations of theft must be apparent. There is a great deal of nonsense in the talk about this matter of secrecy in engineering establishments, for there are few establishments of reputation in which any attempt is made to conceal anything which may be going on. Of course most establishments object to the disclosure of unfinished work, especially when there may be points in the designs which are more or less experimental, or upon which patents may be pending, but when a good design has been carried to successful completion the builders themselves are generally the first to present the results and the details before their professional organizations and place themselves on record beyond possibility of doubt. It is especially worthy of note, in the case of the alleged theft of the boilers of the *Havock*, that they were not as satisfactory as might have been desired, and the design was not repeated. The *Havock* was equipped with two locomotive-boilers of design similar to many others already in use, and these developed on trial only about 3500 horse-power, with an air-pressure of 3 inches. Her sister boat, the *Hornet*, has been equipped with eight Yarrow water-tube boilers, developing 4300 horse-power, with an air-pressure of only 1¼ inches, while at the same time a reduction of eleven tons in weight has been attained.

The nature of the mare's nest which has thus been discovered may be stated briefly as follows: (1) there was little or nothing new about the locomotive-boilers of the *Havock*; (2) they were not altogether satisfactory in their performance; and (3) the construction and performance both of these boilers and those which superseded them in the succeeding boat of the same class had been fully described by Mr. Yarrow himself, before a public meeting of naval engineers, a number of weeks before the alleged theft was "discovered."

THE question of water-tube boilers seems to be coming to the front more and more, and, since the limit of size and strength of "shell" marine boilers seems to have been reached while the demand for higher pressures still continues, it seems as if the water-tube boiler must be called upon to meet the demand, either in its present form or in an improved design which shall avoid some of the present objectionable features. The paper presented by Mr. Charles Ward at the marine division of the International Engineering Congress at Chicago, and the interest in the discussion which it elicited, showed clearly the fact that it is to this type that we must look for the next advances in marine practice. Tubulous boilers have come into such general use for stationary practice that the only considerations which need to be studied for their adaptation to marine use are those of the changed conditions under which they are to be used, and surely the change in boiler construction involved in the use of higher pressures is no more radical, if indeed as much so, as that which has already taken place in the adoption of multiple-expansion engines and twin- or triple-screw propulsion.

EVERY educated engineer will assent to the truth of the statement that power is indestructible, but many will fail to see the many leakages by which valuable power is allowed to run to waste after capture that has cost many dollars. One reason for this oversight undoubtedly lies in the fact that in many cases leakage of power is not immediately perceptible to the senses, so that while our eyes would at once tell of an escape of steam, our noses of a leak of gas, or our ears of an overflow of water, we still remain in serene ignorance of just how much power is running to waste in a journal friction, belt slippage, heat radiation from unprotected surfaces, and all the multitudinous invisible, inaudible, inodorous ways, which, however, are by no means past finding out. The ballad-singer tells us in trite enough words that "the mill will never grind with the water that has passed," but forgets to remark that much of the water has managed to sneak by without performing its due share of grinding. If more attention were given to indicating just how much power was thus leaking away, perhaps more attention would be given to methods of stopping the leaks.

Elaborate calculations have been made to determine just how much power is required to stop a train, but there is an answer to the question which requires no calculation, for it takes just as much power as would start it again to the same speed which it possessed before the brakes were applied. The hissing air-brakes, groaning wheels, and heated brake-shoes all reveal the outlets through which this has escaped, but unfortunately these are outlets only, and never inlets, and as to calling upon this power to help start the train again, that would indeed be a vain call. That such wastages of power might be stored up, to be drawn upon for future use, is not at all impossible. Indeed the very in-instance of the stopping train admits very readily of just such storage, by placing the station at the crest of a grade just sufficient to bring the train to a stop without the use of brakes, the descending grade beyond giving out to the starting train all that was stored during the stoppage.

Another instance of the waste of power appears in the use of resistance-coils in connection with electric motors which are required to perform variable work, and while, in the present state of the art, such rheostats are found necessary, yet their use is about as economical as it would be to open a blow-off pipe for steam when the load on an engine is reduced, instead of advancing the point of cut-off. A device was once suggested to indicate the increase of friction in the journals of line-shafting, it being simply a paint which changed color when a certain temperature was attained, so that any undue warmth of the bearing was at once made evident to the eye of the superintendent. If some such indication of power leakage could be devised for all sources of waste we might find that there were other losses than those due to cylinder condensation, etc., and other objects which needed "jacketing."

WHEN a man proceeds to make a machine of himself and "perform work, accompanied by certain determinate motions," he begins to realize how patient and much enduring his animal and mechanical servants are. Hence he begins to "kick," in more senses than one, when he tries to ride a bicycle which needs lubricating, up a hill which needs surfacing, when he would have given but little thought to either fact had he been driving under the same conditions. The constant efforts of the bicycle-makers to reduce weights without reducing strength or stiffness, and to reduce frictional resistances by the use of the nicest refinements in ball-bearings and the like are almost altogether due to the fact that man is much quicker to discover the effect of wasteful resistances when he himself has to overcome them than when they are not brought so forcibly to his notice.

These considerations are only partly appreciated in connection with details of machine-design, and while forms of construction suggested by the bicycle are by no means to be considered as applicable to machine-construction, yet it may be worth while to "put yourself in its place" when considering the action of forces and resistances in mechanical structures. Even in the case of framed structures a much clearer idea may often be obtained of the true relation and action of the parts and forces by considering the whole as composed of human beings, and imagining the manner in which they would be able to meet the stresses and loads. The ingenious manner in which the cantilevers of the Forth bridge were thus shown is familiar to those who have studied the descriptions given at the time of the completion of that great work. An amusing counterpart may be cited in the attempt to explain to the shah of Persia how the electric telegraph acted. He could understand very well that, when a dog's tail was trodden on, the dog barked, and so he was told that the telegraph was like a very long dog with his head in Teheran and his tail in Constantinople. When his tail was trodden on in Constantinople his head barked in Teheran, and so when the key was pressed in one place the sounder clicked in another. The idea may seem ridiculous, but perhaps there is not such a great difference between nerve force and electric force after all, and the parable may have had more truth in it than its author knew.

THE subject of "inspection" is one which may sometimes bear inspecting itself, and, as it is one with which mechanical engineers often have much to do, it may not be amiss to give it some discussion in this place. Nothing, perhaps, is more difficult than the determination of questions involving the character and perfection of manufactured articles, and the position of the impartial inspector may in some cases be likened to the unenviable one of the umpire of a closely-contested ball-game. When the articles to be passed upon are such as can readily be examined the work may become more or less mechanical, and the inspector at an arsenal, for instance, may acquire a skill and quickness of perception which enables him to detect at once a defective weapon. In other cases the mere presence of an inspector is supposed to act as a warning to the manufacturer and keep him on the watch himself, much as a coal-dealer would be most careful to give good weight when he knew that every load was to be re-weighed. These, however, are hardly instances which demand engineering skill or ability. In many cases, however, processes as well as products have to bear inspection, while selected samples to which exhaustive tests have been given are taken as representative of the lots from which they are taken. It is in work of this kind that the ability of the specialist is demanded in the highest degree, and there is no position in which thorough special training and acute perceptions are more necessary.

Unfortunately, inspectors are often chosen for other considerations than those of personal skill or special knowledge of the subject under consideration, and many instances are known in which deceptions have been carried on under the very observation of those who should have seen just what they failed to detect. In some cases articles which have been condemned have been put aside for a short time and then presented again only to pass "inspection" without an idea on the part of the inspector that they have ever been seen before.

IN discussing the subject of aërial navigation it generally has been assumed that the flying-machine should carry its own source of motive power, and many efforts have been made to produce motors of exceeding lightness in proportion to their capacity. While this method must be very desirable for many purposes, it may be worth while to note the fact that, for the more recent forms of surface transit, such as cable and trolley roads, the advantages of central power-houses are prime considerations. It may not be found impossible to adapt some modification of a "trolley" system to aërial transit, thus enabling the power to be delivered to the motors by trailing connections. There is no absolute necessity for high flying, at least for commercial purposes. The real value of such a system would lie in the absence of expensive road construction.

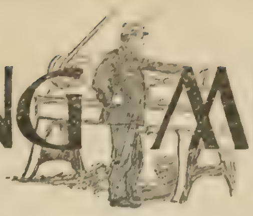
IN this connection it might not be impossible to solve the problem of the ablition of the unsightly overhead trolley-wire for surface roads, by the extension of some such method as that adopted for the purpose of telegraphing to and from moving trains. This, as is well known, is done by the induction action of a current passing through a wire at a moderate distance, upon a coil passing about the car, there being no metallic connection whatever. Could a motor on a car be operated by a current passing through an entirely-buried conductor without the necessity for metallic or other contact, the problem would indeed be solved. This, however, we must leave to our electrical colleagues for their respectful consideration.

REFERRING again to the question of inspection of products and processes, it is interesting to note that while engineer officers of the United States navy are acting as inspectors on most of the work which is being done upon the several warships now under construction, the inspection of armor-plates, both at Bethlehem and at Homestead, has been and now is done entirely by *line* officers, none of this work having been inspected by engineers.

MENTION was made last month in this department of the fact that many engineers in the navy have found it to their personal and pecuniary advantage to resign from the service of a government in which ability is recognized neither by rank nor by compensation. These remarks have since been emphasized by the resignation of Chief Engineer N. P. Towne, in order to accept a position with the Messrs. Cramp, of Philadelphia, at whose establishment he has been acting lately as inspector. The injustice which has been wrought by the distinction of rank between "line" and "staff" officers in the navy probably has as much to do with these frequent resignations as anything else, and the efforts which are now being made by the staff officers to secure absolute, instead of "relative," rank should be crowned with success if we are to have men of ability willing to remain in the service. A modern war-ship is probably the greatest aggregation of the work of the engineer which can be found anywhere within the same limits of space, and surely methods of organization and discipline should keep pace with the transformations in construction and operation. A fighting-machine must be *fought* by engineers as well as built by engineers, and it may be that the officers of the line will awake to the realization of their false position only to find that there is no further occasion for their existence at all.

THE indicator is to the engineer what the chronometer is to the navigator, and the reliance which is placed in the indicator-diagram should be based upon similar methods of correction and calibration. No horologist attempts to claim absolute accuracy for his chronometers ; he is satisfied if he can secure a practically constant rate of error, and this rate is determined and re-determined periodically by comparison at national observatories so that the application of the ascertained correction will enable a degree of accuracy within the required limits to be obtained. A like method of calibration for indicators is entirely in accordance with modern methods, and Chief Engineer David Smith, U. S. N., in his paper before the Engineering Congress at Chicago, very properly observed that to attempt to correct an indicator at the spring is about as likely to prove successful as would be a similar attempt at the mainspring of a chronometer. By using a given indicator to measure quantities of power already accurately known, it is practicable to construct corrected scales for use at various speeds and conditions corresponding to those under which they were calibrated, and thus, by applying the universally-accepted method of working from the greater to the lesser, we may feel confident of the accuracy of subsequent determinations within the range of the original limits of observation.

THE YOUNG MECHANIC



Conducted by Frank Williams.

SOMEBODY suggests that we misquoted Bacon last month. It is not a new thing to take liberties with a familiar quotation and to find in it something that the author never put there. "We are the ancients because we know it all" was not a fair version. We are the ancients, indeed, if there be any, because we have inherited the accumulated knowledge of all the ages; but still are we far enough from knowing it all.

The underlying idea of it, so long ago recognized and formulated, but needing constant reiteration, is that the best informed and the fullest equipped has always the advantage. Stated mechanically, it means that if if we are are to work and win we must have a full kit of tools. Looked at in a business way, it means that we must have capital to carry on the business of life successfully. The individual young mechanic, as much as the biggest merchant or manufacturer, must have and must continually accumulate capital or he can't get along. We should always be able to do not only what we are now doing but more and bigger things bye and bye. Who knows of any established and prosperous business that is not also and always a growing business? Sometimes it may grow faster than at other times, but it is the almost universal law of business life to either grow or die. There is no such thing, for a very long time, as just barely living. If we could remain stationary, things around us would not. "Marking time" or rowing against the stream without gaining on it is never kept up for very long.

WE hear much in these days of the continual narrowing of individual occupations. We hear, what is the simple truth, that every worker and every student is becoming continually a more minute specialist. Some young fellow may take this the wrong way. He may say that as he is a mechanic and seeking the fullest equipment for mechanical occupation he must read and study nothing but what is strictly mechanical, and so may think it his duty to actually narrow the range of his knowledge. In these days we each learn to do the one thing instead of the many, but we are apt to find that to do the one thing well we need to know more than in the olden time we needed to know to do the many things. Raising water is one of the primitive occupations, and if it be lifted in a bucket there is not much to know. There may be some choice in the size and shape of the bucket and in the best adjustment of the handle of it, and that is all. But to lift water to-day we must know all about the complex, high-pressure, multiple-expansion, condensing pumps with exhausting reports. That is the way in which some of our occupations have "narrowed."

The fact is that to know the one thing completely we need now to know everything and a little more. Here is an illustration on the spot. Not every mechanic who saw *Harper's Magazine* for March of this year saw more than one mechanical article in it. There were in fact two, without even hinting at a third one. Probably even the editor of the magazine in making it up thought the second article referred to a good set-off or contrast and as far as possible in topic from the pronouncedly mechanical article upon "A Steel Tool." Thet mechanic must have been hopelessly lacking in that true, wide-reaching, all-embracing, instinctive interest and sympathy that belongs to him if he did not at once recognize as his true food "The Welcomes of the Flowers," by Hamilton Gibson. The article about steel of course every mechanic who saw the magazine felt it his duty to read. Those who were well informed upon the subject had to read it to see that it was all right and those who were not so well informed had to read it for the sake of what they could learn. If any pseudo-mechanic then looked through the magazine and did not "catch on" to the flowers his case is a deplorable one. But from a mechanical standpoint what was there that should especially interest us in "The Welcomes of the Flowers"? First, then, there is in the true mechanic the ability to appreciate excellent work wherever it is found, and none the less if the work be widely different from his own. Who ever saw such dainty art work as Mr. Gibson's pictures of flowers and insects? They have their full right to be merely in the pleasure they give to those who may be allowed to see them. But as illustrations of nature's devices for the performance of a necessary mechanical function they have their special interest for us. We learn from them more of the interdependence of created things, and that a flower cannot live an independent individual existence any more than a mechanic can. By the "welcome" of the flower is meant its invitation and welcome to the insect whose office it is to effect its fructification, and without whose visit the flower must die and leave no successor upon the earth. The flowers to secure the visits of the insects offer their inviting cups of honey, with gay colors and pleasant odors to attract, and lines pointing unmistakably to the storehouse of the sweets; but when the insect comes the flower plays its little trick upon him and sends him off bearing the fructifying pollen to some distant flower, and thus the work of cross fertilization is kept up. The endless variety of ingenious mechanical devices (most of them patentable) for accomplishing this purpose cannot fail to find appreciation in the true mechanic who will look into them, and cannot fail to be of help to him in his mechanical education and development. And then when we have taken our fill of these ingenious mechanical devices merely as such it will be strange indeed if the function that they perform does not itself offer its pregnant suggestion to us. How about the cross fertilization of the mechanical mind? Of the fruit already garnered in our modern life how much of it all has come to its ripened perfection and bestowed its richness upon us but through the cross fertilization of the human mind? What are we doing and what shall we do for the promotion of a function so necessary and so beneficent?

HE that knows only just what he himself knows knows nothing. He must find some source or many sources from which to fill up or he will blow away, or he should be blown away. Much may be done by reading and study. We don't read many books now, they say; still we read much and we pick up much as we read. What used to fill the books now fills the periodicals of the day, and it has a wider distribution than ever before; and between those who get it and those who do not get it there is a boundless difference. Still there are many things that are not caught, or not easily caught, in this way. And not only "things" are missed but more especially the true inwardness and spirit of things are missed. We distinctly favor the journeyman idea. Every young mechanic should if possible—and why impossible?—see other shops and other work and other ways than his own. He can not only get items of knowledge or practice that are too familiar to be mentioned in print, yet far too vital to be missed, but he will also be generally spurred up and quickened if he has anything in him. The best pace is never got out of the racer unless somebody is after him. Besides all that the young man gets as he goes along there is also what he carries, and which he can bestow where he will, and which he often unconsciously distributes and still is none the poorer. The bee thinks only of honey as he goes, and not at all of cross fertilization, and so the young mechanic may think only of looking for a better job here and there; still there is little doubt that if he be one whose work and influence would be of value in any fixed place they are enhanced by a wider experience and contact.

WE are far enough from counselling the young man who is doing well and is appreciated to rudely sever his connections and cast himself adrift on the world. He may, however, keep his eyes open for all chances of visiting other establishments as he has opportunity, and he may plan his vacations and excursions so that they may add to his chances. He may thank his lucky star that he is in a land that is unique in its opportunities for seeing and knowing. We think much of the open-hearted and liberal policy that has always prevailed in our country. As a rule the visitor has had the freedom of the American workshop so far as the study of means and methods was concerned. We have no trade secrets that all the world may not know. There is no doubt but that this liberal policy has contributed greatly to our general advancement. As industrial plants become larger the requirements of discipline seem to call for tight fences and watchmen at the gates, but we will be sorry to see our workshops like the sealed establishments of the old world.

THE United States government sets a noble example of our characteristic unsuspecting and generous and unostentatious habit. The other day we went through the formality of asking for a pass to visit the gun-factory at the Watervliet arsenal, and we have been wondering ever since what the pass was for. We had no use for it. We were free to go wherever there was anything to be seen. We could see whatever we would of the splendid equipment of machinery and the monstrous and marvelous guns, in all their details, and in all the stages of their production. It is very certain that we could not have done the same anywhere in Europe; yet what is gained by all their childish precautions, and what is lost or risked by our open-hearted confidence and liberality? Any reader of this may see as much as we saw. We have always found ourselves free to visit all similar government establishments anywhere. A visit to Washington is a pleasant memory always, for the hospitalities of the government departments and the sense of proprietorship that is everywhere suggested to the visitor. Proprietorship without care is as far as the antipodes from the care without proprietorship that is familiar to most of us.

As we are surrounded with opportunities both public and private, we will avail ourselves of them when we can, and if it comes to us to change our field of activity and usefulness we may regard it as a move in our favor rather than otherwise.

NOW here is a young fellow who has overdone the business. Even good advice is to be followed with judgment and moderation. We knew the writer of the following letter as a young pattern maker of say average ability working in a shop with which we were connected in New York. The letter it will be noticed was written at Chattanooga, Tenn. Our reply was despatched with reasonable promptness but it failed to find the young man who had by that time gone to Chicago, and it came back to us, like Noah's dove, while he is still flying over the land in the vain hope of learning all there is in it.

WE happen to possess in active intensity that true mechanical instinct, that by the unreflecting is often called laziness, but which is in reality a form of self-respect and appreciation; we mean the aversion to waste exertion or to allow anything when done to fail of all effect; and so if we ever write anything it goes hard with us if we do not eventually compel some one to read it, or if they don't read it the sin is upon their own consciences rather than upon ours. Here follows the correspondence:

DEAR MR. GRUMBLER:

I beg pardon for taking the liberty of writing to you, but as you occasionally help out young men with your etc , etc., I thought that you would not be offended and might be willing to help me.

I am interested in the construction of machinery and I want to learn as much as I can of every branch of machine construction. I have spent several years as a machinist and several as a pattern maker, and now I want to learn to be a good practical blacksmith, or at least to have a fair knowledge of blacksmithing, and I want to get into a place where they do extra fine work like Maltster's Carriage Co. of New York. After I have mastered light blacksmithing I will try heavy work. Now, Mr. Grumbler, under what conditions do they start a beginner at that trade at Maltster's or at any other place in New York? My age is twenty three and I have worked, as I said, at two trades already, and am quite certain that I could do the same or more in two years than some would do in four years serving. (The writer of this letter was not of American birth.) Do you think firms would make an allowance in this respect or employ only under certain fixed rules?

Wishing you a Happy New Year and thanking for your favor, I remain yours respectfully,

OMNIVOROUSAMBITIOUSCUS.

Chattanooga, Tenn., January 1.

OUR REPLY.

MR. O————SCUS:

Dear Sir: I thank you for your kind wishes, and heartily reciprocate the same. Your determination to push yourself along is the correct idea, and your confidence in your ability to "get there" is not a bad thing to have, and I would be glad to help you. I think, though, you are making a mistake in trying to become a Jack-of-all-trades. He is a fellow of whom I never heard a good word spoken, and I do not know that he ever deserved a good word. The world has no use for him, and the deliberate and established opinion of the world is one of the most reliable things in the world. Adam had a perfect right to be a Jack-of-all-trades; but he should have been the last of the race. Ever since his day the trades have been dividing and subdividing and narrowing, and therein have found all skill and excellence and success. If you are as successful in life as you of course hope to be, you will bye and bye have a house of your own, and then naturally you will do your own plumbing and paint your own pictures, because by that time you will be able to do all these things, and as you do them yourself you will of course do them just as you want them and you should be a happy man. Then, again, things may not turn out just as you expect, and it may be as well to travel in the good old ways. It would be better for you, it would bring you better wages now and open a better chance for you in the future if you would stick to one thing, and I don't know any trade better to stick to than pattern-making. It seems to me strange that you, being a pattern-maker, and anxious to get along, do not see that closely allied to it are drafting on the one side and molding on the other, and that you should look in these directions to supplement and add to the skill and knowledge you have already acquired, and make it all count together for your substantial advancement. An expert molder is very unlikely ever to be an expert pattern-maker, but nobody is better fitted for a critic and teacher of pattern-making, and no pattern-maker is more than half a pattern-maker if he does not know much about molding. Then the pattern-maker has to know about mechanical drawings, to be able to "read" them, and to follow them accurately in his work, and he should also be able to make a drawing, and the better he can do it the better it will be for him. Good draftsmen to-day come some of them from the work-bench and some of them from the technical school, and, so that they arrive in good condition, it makes little difference from which direction they come. The draftsman, when he has become reasonably expert with the drawing, may turn his attention to the study of the thing drawn, and then the whole field of mechanical industry opens before him, a field so wide and vast that he can only hope to invade some chosen section of it. The thing to be always borne in mind as most essential is thoroughness and completeness in the pursuit of the thing at any time occupying your attention.

Referring to your specific question, I would say that it is difficult to get a chance to learn blacksmithing anywhere, because no one can spare a fire for a beginner, and I don't suppose you could make any arrangement to begin the trade at such a place as Maltster's carriage factory, and if you got in there you could not acquire skill as fast as you could in a little busy jobbing shop. Expert all-around individual workmen are not produced in "factories" and are in little demand there.

I of course do not know just what you propose to make of yourself, or what you think of fitting yourself for, but I cannot imagine any mechanical position to be filled the fitness for which would be best promoted by the all-around trade practice that you propose for yourself. An able superintendent or proprietor may and often does become an excellent critic of all the men under him and of what they do, but that is a very different thing from being able to do everything himself.

I like to speak plainly what I think, and that seems to be all that I am able to do for you, and if it helps you at all I shall be glad.

Yours truly,

DYSPEPTIC GRUMBLER.

THIS style of young man comes along very frequently looking for a job and telling you that he has worked in most of the prominent shops of national reputation in your line of business in different parts of the country, giving the names of firms familiar to every one and often volunteering additional particulars about their shops and shop methods. It is sad to say that these peripatetics do not always tell the exact truth about their travels and workshop experiences. We, however, pride ourselves upon our ability to always exhibit a bland and childlike faith in the veracity of every narrator, and in these cases we generally tell the applicant that the firms they speak of have attained their success and eminence by retaining their most promising workmen and not by scattering them over the land, so that it is no recommendation to say that you have been in the employ of many prominent firms unless it is also clear that you have trailed a broad streak of regret behind you. Business capital in manufacturing consists not alone in money in the bank, in fine and roomy buildings, in the most improved machinery or in the best and fullest facilities everywhere. Much also of manufacturing success has lain and still lies in the accumulation and retention of skillful and experienced and faithful employés. When an establishment is closed for an indefinite period, and the men are scattered and lost to it, it may be possible to start the engine and shafting and machinery at a day's notice, but for lack of the trusty men it may be long before everything is running again with its accustomed smoothness, reliability and profit. When a pessimistic spasm comes over us as a people, and we get a little taste of the calamity our foolish fears have fostered, and the industrial establishments are closed, and some worthy men are taught the bitter humiliation of having to "beg their brothers of the earth to give them leave to toil," we have to some extent a new deal in skilled labor, and one employer's calamity becomes another's opportunity, and between them the valuable mechanic is not long left out in the cold.

WHILE we are going along trumpeting the praises of the present as being in truth "the good old times," if there ever were any, some folks will be accusing us of being too optimistic; so as to balance things, and to make these good people happy by showing them that they are not really so well off after all, we will have to give a little of the other side of the case, and the way to do it is something after the following fashion. It happened to us in our youth to be a neighbor to a little wiry Frenchman who had two little daughters whom he set out to drill and train into accomplished musicians. Their exercises were begun as soon as they could walk and talk, if not before that, and were kept up incessantly. When they were at the piano their father stood over them with a little rattan to rap their knuckles if a mistake was made, and, whatever may have come later, their earlier years were not happy ones; but as the result of the unrelenting discipline one of the little musicians became Madame Albani. We once saw a very little child brought on the stage all doubled up in a carpet bag, and that little child is now perhaps the greatest of living contortionists. So it is with each supreme instance of excellence, whether in art, in acrobatics or in mechanics. Art is long and life is short, and there is no time to waste, and our training should begin in our tender years. There need not be cruelty but there should be opportunity and constant exercise tending in the direction of the successful life occupation. In this view of the case the life of the incipient mechanic in these latter days is not all that it might be, and he doesn't have the start that he might have, nor even such a start as he would have had if he had begun his active career in the fifties or the forties or away back. One American institution that was the nursery and the primary school of the American mechanic has disappeared or is rapidly departing from all our towns and cities. The woodshed has gone forever where we used to tinker and invent and make boats and kites and windmills and waterwheels and wagons and churns, and where we used to have shows of various kinds and meetings to organize societies or get up imposing processions. It has gone never to return and nothing has come into the life of the budding mechanic of to-day to take its place. Two or three years ago we were in Minneapolis and we found the institution still maintaining a struggling existence there. On one we saw a sign announcing a circus that was to be held "next Saturday, all day, admission ten pins," and we were sorry that we were not able to attend. On another one there was a sign "Punkins dugout, Lanterns for sail." The price was not given or we might have bought one. This is meant in all seriousness. We have no doubt, in fact we know that the American woodshed has evercised an important function in the development of American mechanical skill and its departure is to be regretted.

The attic, where it exists, is no substitute for the woodshed. It may do for the individual tinker but there is not the freedom for the neighbor boy to come and go as he will, and when it comes to invention, or to execution either, one boy is to two boys as $1:2^5$, and from that upwards according to the boys and other things. With the attic also there is not the freedom as to noise, nor the freedom as to matter out of place, so that it carries with it limitations that are fatal to any worthy developments. We hear sometimes of attic philosophers, and for such cheap stuff as that it may do; but we are not likely ever to hear of the attic mechanics.

COMMENT & CRITICISM

A National School of Mines.

IN the February issue of THE ENGINEERING MAGAZINE I was much interested in a criticism by Mr. Richard A. Parker, entitled "The Cost of Mining Schools." While he takes occasion to make a severe and a rather "one-sided" comment on the folly of the establishment and state maintenance of so-called mining schools in the west, the subject is doubtless a timely one, and certainly calls for opinion from more than one quarter, although Mr. Parker evidently takes it for granted that his view of the matter, as given in his published comment, will be accepted as final and decisive. It would also seem that Mr. Parker, while making no direct allusions, advocates the total abolishment of all western mining schools and unmistakably intimates that the Columbia School of Mines possesses all the essential requirements for a national school for the training of mining engineers. The New York school is unexcelled as a technical institution for the theoretical training of engineers, but the fact should be apparent to Mr. Parker that the location of this school on the Atlantic coast, so far removed from any important mining region, would preclude the idea of its ever becoming a "Mecca" for mining-engineers-to-be.

In the United States to-day no medical student can receive his degree without having had actual practice in the hospitals, nor are any naval students graduated from Annapolis who have not served their term on ship-board; but it is nevertheless true that young men being fitted for a profession equally as important—*i. e.*, mining—*can be*, and undoubtedly *have been*, graduated from the New York school without ever having been inside a mine, excepting a few possible trips to some neighboring stone-quarries and collieries. But, in the face of all this grave neglect of the practical part of their education, these same young men, after securing their degrees, are frequently intrusted by mine-owners and capitalists with positions of the greatest responsibility, to which fact, undoubtedly, some of the heavy losses attendant on so many mining enterprises are directly traceable. Such a man as this, with his degree of E. M. in his pocket and no practical experience whatever, must necessarily spend two years or more at actual work in the mines before he can gain even a fair idea as to what constitutes the duties of a mine-superintendent.

It is generally and rightly conceded that the most reliable and successful mine-superintendent of to-day is the one whose training embodies the practical as well as the theoretical part of his profession, the one being of little value without the other. But, as can be imagined, a miner at work underground has no time to devote to the study of calculus, hydraulics, and mechanics, nor can the student in our eastern technical schools spend any time at practical mine-work and at the same time maintain his class standing.

The truth of these statements will be evident to any one who knows the least thing about the subject, and it seems hardly necessary to add that a satisfactory solution of the question can be had in meeting the demands of theory and practice each half-way and establishing a large, well-equipped mining school at some point where mining is the chief industry, in the midst of some district where, for a hundred miles in all directions, are mines of gold, silver, lead, copper, zinc, iron, and coal; where monster smelters rear their tall stacks in nearly every town; where the atmosphere is laden with smelter smoke; where every other man depends for his livelihood on mining and its allied industries; where, in fact, the very rivers and streams are discolored with the waste of mines and stamp-mills and reduction-works. As a student amid such scenes, what ideas would be imbibed, what grand lessons would be learned, and, above all, what enthusiasm and interest would be aroused and stimulated by witnessing daily such practical illustrations and demonstrations of the lectures and theories of the class-room.

Such a location as mentioned is not ideal, alone, but both real and possible, there being not a few places in the United States where mining and metallurgical interests are so concentrated around a common center as to offer inducements for the establishment of a national mining school that are vastly superior to any advantages that could possibly be afforded by a seaboard city like New York. It may be mentioned that no state in the union has stronger claims for recognition in this respect than Colorado, which, as its mining and smelting statistics show, surpasses all other states in the vastness and wealth of its iron and manganese deposits, its coal-beds and its mines of gold, silver, and lead, together with the mills, smelters, and reduction-works that are necessary adjuncts in the treatment of these products.

There are only three mining schools in the country to day that take an active part in the education of reliable mining engineers and metallurgists—the schools at New York, Golden (Colorado), and Houghton (Michigan). The geographical, and I might say geological, location of the former school is greatly to its disadvantage, as stated, but were this excellent institution so situated as to render accessible at all times to its students all kinds of mines, metallurgical establishments, and the long train of industries pertaining thereto, much of the talk about incompetent "specialists" (so-called) would soon cease. As things now are at Columbia almost all the mining and metallurgical operations and methods are taught and illustrated by means of models and charts, which, though of great value to the student in showing him *why* such and such an operation should be done, cannot, for a certainty, give him any very definite idea as to *how* it is done; for the countless small points and details which are continually being observed in actual practice cannot be explained by any such system of maps, models, and charts as are now in vogue at this school of mines. A student can easily learn from his text-books, lecture notes, and models how to build a cupola furnace, but the ability to mend a broken slag-pot or remodel an old mill or smelter cannot be derived from the same source. These are things which he must learn for himself after he leaves college and goes to work in the mines, but they could just as well have been learned during his student life IF his college had been so located as to bring its students into intimate contact with the very things they are striving to learn about. A well-known western engineer once said " it is just as easy to learn how to mine from charts, models, and such as it is to learn marine engineering in a barn-loft on a Kansas ranch." The truth contained in this terse remark is not hard to realize.

Of the Colorado School of Mines too much cannot be said in favor of its location, which is certainly superior to that of any other mining school in America and probably in the world. Its growth has been steady though hampered somewhat by adverse legislation, as is inevitably the case with state institutions. Its popularity, however, is increasing yearly and had its financial resources been less limited it would long ago, as it is even now inevitably destined, have taken front rank as a school where both the theoretical and practical training is relied upon to produce that most desirable of professional " products " —a mining engineer who, from the outset, is actually able to distinguish between a lead-smelter and a quartz-mill, and who, moreover, does not possess an endless array of class-room theories which have to be " unlearned " before he can become of any service whatever, around a western mine, at least.

An hour's ride in any direction from this Colorado school will take the student into the very heart of the greatest smelting district in the United States, while a day's trip at the most would enable him to investigate for his own satisfaction and instruction anything in the way of mining and metallurgical methods or operations he may desire.

The Houghton school is considerably the smaller of the three but possesses an able faculty and an admirable location in a region where mining is conducted on a scale unequaled by any other part of the world. The chief drawback here, however, is due to the fact that all the accessible mines are either iron or copper, with practically little difference in their workings and methods of operation, so it is no more than reasonable to suppose that the graduates of this school know little or nothing about the mining or metallurgy of the precious metals excepting such theoretical knowledge as might be acquired in the class-rooms.

It will be observed that each of these institutions has its own peculiar advantages and well serves the purpose for which it was originally intended, but when it comes to a question of a National School of Mines every effort should be made by those interested to have erected and equipped such an institution for the training of engineers as will serve as a model for all nations. Last, but not least, there should be embodied in its *situation*, construction and equipment all the essential features and important advantages of those schools now in existence with *none* of their defects and disadvantages.

PERCY WILLIAMS,
Editor *School of Mines Scientific Quarterly.*
Golden, Col., March 1, 1894.

Preservation of Metals from Corrosion, by Electric Polarization.

A PARAGRAPH in the April issue of this Magazine recalls to the undersigned suggestive points that have been in his mind for years. The paragraph referred to is one in the department of "Mining and Metallurgy" relative to the corrosion by *mine-waters*, of metallic surfaces exposed thereto.

The class of evils here exemplified is very widespread, indeed. It is not only in mines that iron and steel meet their chief natural enemies, water and carbon-dioxid, or rather—when the water and carbon coëxist—their one worst enemy, carbonic acid. Metallic salts and acids in mine-waters intensify the corrosion, by decreasing the resistance of the water to voltaic circuits, the corrosion of metals by liquids being voltaic phenomena, in all cases. Acids and acid salts, which, are capable of taking up iron oxids into solution, still further enhance the destruction, by removing such oxids—which would otherwise remain more or less a protective coating. But the saline matter in solution, that exalts the voltaic action, need not be acid. Any *neutral* salt which decreases the resistance of the water will qualify it to act as the necessary liquid medium of a voltaic circuit. Sea-salt is the commonest of all such neutral salts. Together with other chlorids and the sulphates of sea-water, it enables corroding voltaic action to be set up on all iron and steel surfaces immersed therein.

But the question may arise with some, how can a voltaic circuit exist where *but one metal* is present? Two metals, whose affinities for oxygen differ in degree, are needed. True, but are we considering a case of but one metallic surface continuously uniform in its affinity for the oxygen of the water? Practically *never*, in case of the ordinary forms of iron and steel. Their surfaces are never homogeneous in composition (that is, in proportions of carbon, silicon, sulphur, etc.), or in density, crystalline character, electric conducting power, and so on. The tendency of chemical and microscopic researches is cumulative in this direction.

And the moment corrosion begins, this heterogeneity of surface increases. It is a familiar fact that when a corroded spot appears, it must at once be rubbed off, or polished out, or it spreads. "Rust eats into metal." The trouble referred to in Mr. Williams's Department is not therefore by any means one peculiar to mines. All our iron and steel *vessels*, inclusive of their hulls, machinery, and boilers; indeed all steam boilers and steam machinery, on sea and land; all iron buildings, iron and steel bridges, inclusive of suspension bridges; all iron roofing, iron fencing, iron paving, and all underground iron mains, especially water-mains, are more or less liable to this same destructive agency, of voltaic corrosion.

This agency, as shown by numerous developments of modern research, is not confined to the superficies of the metal. Minute flaws, pores, and fissures are very liable to occur in masses of iron and steel, which, though imperceptible to the eye, will admit liquids; and it has quite recently been shown that, by reason of the want of homogeneity already referred to, *thermo-electric* currents arise within such masses during every change of temperature. Such currents must set up voltaic action within such cavities or fissures, which, though slight, will in time enlarge these cavities sufficiently to sap the strength of the mass. Wire cables, so often used for hoisting in mines, as elsewhere, are liable to such insidious internal corrosions, and calamities have thus arisen.

The mode which the present writer has to propose, to obviate and largely diminish, if not altogether terminate, these dangers and losses, and ruin of costly structures, is to muster against them electric energy itself—figuratively, to "fight fire with fire." If a mass of iron is exposed to the corrosion produced by superficial or internal voltaic circuits, such metal is to be made, as a mass, the negative terminal of a much *stronger* circuit, from a dynamo-electric engine, while the corrosive liquid is made to bathe the positive terminal of such stronger circuit.

Many mines and most iron steamers are now provided with electric generators, and this protective agency may in numbers of cases be applied with little additional cost. The currents required, short-circuiting being of course excluded, will not be large.

For mines, a small generator, operated by some small water power, which will work night and day, will be best. The positive pole of such generator should be carried through an insulated wire down to the lowest pool of water in the workings on which the pumps operate (terminating in a body of hard-burned coke), while branches of insulated wire from the negative pole should be carried down a shaft, and thence through every gallery, with frequent points of attachment for branch wires, which may be connected permanently with fixed metal articles, as lines of rail, drilling machines, pumps and pipes, ladders, etc., and temporarily with movable articles, as iron cars, wheels, tools, etc. In one case, that of "fiery" coal-mines, this plan may not be feasible, for obvious reasons.

In the case of iron-vessels, the hull must be made negative, as well as the boiler-shells, the cylinders, machinery, shafting and propellers; while the positive pole will pass into the open sea, with a terminal of large surface, of hard carbon. In the case of plain boilers, without many flues, their water may have immersed therein a large flat plate of battery-carbon, with glass supports, attached to an insulated negative terminal wire which passes through a hard-rubber plug set in the boiler-shell. In the case of marine condensing engines, no *incrustations* should form on this carbon by electrolysis, which may with ordinary waters prove an obstacle; though such electrolytic incrustations are not likely to be hard and stony, like others. As for any acids, or even chlorin, if such should possibly be freed by electrolytic action, these could do no harm either to boilers, valves, or cylinders, so long as the latter are all kept in the electronegative state.

With reference to corrodible metals in general—other than iron and steel—space permits but the remark that the principle is applicable, in duly modified form, to all these likewise.

HENRY WURTZ, PH.D.,
No. 2149 Seventh avenue, New York.

Costly Economy in Railroading.

MR. SIMMONS'S very clear and conservative paper on "The Outlook for an Improvement in Business," in the April number of THE ENGINEERING MAGAZINE, contains a paragraph on the railroad situation which seems to call for further remark. The writer says:

> It is true that the railroads which have not been embarrassed show a heavy decrease in gross earnings, but there has been a corresponding heavy decrease in operating expenses, as a result of which, in some instances, the current reports

show an actual increase in net earnings. This would indicate a comparatively healthful state of the financial condition of the railroads.

On the face of bookkeepers' balance-sheets and net earnings that may be quite true in one sense, but the statement needs some qualification. There are other considerations to be taken into the account, which do not appear in the companies' current reports, but which are bound to make themselves felt in the long run and which have already begun to show injurious effects. Further on Mr. Simmons adds:

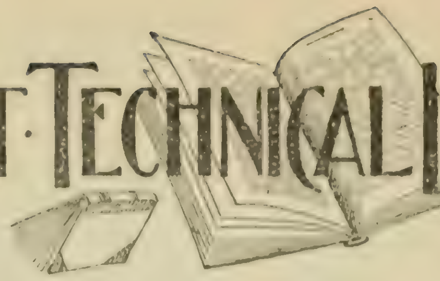
> Another favorable feature of the situation grows out of the economy which the railroads have been practising. Since the date of the Baring failure, in 1890, the railroads have been reducing expenditures—a fact well known to those in the business of selling supplies to railroads—and since the panic of last summer they have been forced to the very limits of the most rigid economy.

Mr. Simmons explains that the railroads "must soon be in the market again for supplies"; but that is putting the case very leniently. Many of the roads have shut off repairs and renewals of line and equipment to a most hazardous extent. A well-built road, starting with its track, bridges, rolling-stock, and miscellaneous equipment in the best of order, with the usual reserve supplies on hand, can be operated for a certain short period, say a year or two, on its existing plant, with very small outlay for keeping up its condition. But that time of grace speedily runs out. Whatever is then seemingly saved has to be made good sooner or later, for the original plant rapidly deteriorates under such a policy. In the end the cost of putting a road back into full effective shape by one general overhauling is likely to be greater than if the repairs and renewals are kept up *pari passu* with the wear and consumption. But meanwhile a more serious trouble comes in—the increased number of accidents, or at least those justly attributable to depreciated plant and underpaid labor. I have no recent statistics at hand, but it is a matter of common remark that railroad accidents have multiplied of late,—especially the minor ones. Observation in a railroad center whence there are many radiating lines clearly shows this. Even the newsboys here have got into the habit of calling out as the stable inducement to buy the evening papers, "Terrible wreck on the ——— road!"

Those roads which are now in the hands of receivers are being operated with a more cheese-paring policy than the financially stronger lines. In reducing wages they have not caused as serious strikes as would occur at other times, for the men recognize the necessities of the situation and are themselves in poor shape to inaugurate a contest, while there is so little other work for them to turn to. But when "economy" is pressed too hard upon men of such grave responsibility as train-despatchers, telegraph operators and others to whom are entrusted the lives of thousands and the property of the road, and who are overworked and discontented (if not replaced by inefficient men), the results are inevitable. "Rigid economy" goes too far when it forbids the renewal of broken signal lamps. Life, limb and property are things that have to be paid for; and the longer the present system is continued the greater will be this concomitant drain upon the companies' resources. It must be remembered, too, that before this era of ultra-retrenchment had begun, fierce competition had forced railroad managers to as close regulation of expenditures as was prudent. To go beyond this was unsafe, as is already amply shown. Of course managers understand this fully, and their action is by no means a matter of choice.

A PASSENGER.

CURRENT TECHNICAL LITERATURE



MACHINERY FOR METALLIFEROUS MINES: A PRACTICAL Treatise for Mining Engineers and Managers of Mines. By E. Henry Davies, F. G. S., E. M. With upwards of three hundred illustrations. London: Crosby Lockwood & Son. New York: The D. Van Nostrand Co. [Cloth. 8vo. xvi-564 p. $5]

THIS volume is designed as a companion to the well-known work on "Metalliferous Mines and Mining," by the late Mr. D. C. Davies, F. G. S. (whose son the author is), and is devoted to the description of the various machines and appliances in use in mining, both for the extraction and transport of the ore and for its concentration and preparation for market, The author qualifies this by limiting the scope to "machines in daily successful use"—a point well taken, and in the main adhered to. He further explains that it does not "attempt to exhaust the list of the numberless new processes and new patents which the fertile brains of inventors are almost daily bringing before the public, only too often to attract a brief attention and never to come into practical use." Indeed, as it is, the feature which will first strike the reader is the perhaps too-extensive field sought to be covered by a single volume; for mining machinery proper would seem to be quite large enough a subject, without attempting to include matters which might better be left for another volume on metallurgical methods and appliances. But it certainly is a pleasant relief to note the omission of descriptions of antiquated and merely tentative devices, usually quoted with wearisome repetition in similar works; and the author has done wisely in giving his main attention to actual modern practice. In this respect the book is more nearly up to date than any other compilation of the kind, and therefore commands high appreciation.

The subject-matter is arranged under the following heads: Water as a motive power; wind-engines and ventilating machinery; steam-boilers, steam-engines, and oil-engines; hoisting machinery; the drainage of mines and pumping machinery; rock-drilling machinery; boring apparatus; coarse and fine concentration machinery, sizing and classification trommels, jigging, etc.; the milling of gold-ores, milling of silver-ores, amalgamating plates and machinery; the chlorination and cyanide processes for the extraction of gold; concentration mills or dressing floors for the ores of lead, zinc, copper, etc.; electricity as a motive-power for mining-machinery; electric lighting and blasting; aërial wire-ropeways and wire-ropes; and transport by rail and road. This mere outline at once calls up an impression of the magnitude of the task undertaken.

The sections on steam-pumps, etc., contributed by Mr. Philip Argall, of Denver, are particularly good. The series of chapters on concentration are also well prepared. The compiler seems not to have drawn so largely as is unfortunately the prevailing custom upon older and partially obsolete reference-books, but has followed current literature and the experience of himself and associates. Possibly in some cases he has relied too implicitly upon the trade circulars of foundries and machine-shops; but this is the simplest way of keeping abreast of the times in mechanical progress, and such publications have latterly become very useful.

Careful as Mr. Davies has been, it was inevitable that many omissions should occur, which will be suggested to technical readers, while some of the matters briefly discussed deserve treatment in more detail. It may seem captious to object to anything in a work so admirable, but one cannot but regret that the sections on gold and silver amalgamating-mills were not stronger. Silver-milling is not dead yet, in spite of being steadily supplanted by smelting and other methods. But it must be remembered that any one of a dozen sub-topics touched upon would in itself furnish a theme and material sufficient to fill a more bulky volume.

The field is viewed through English spectacles, but there is a great deal concerning American practice and continental practice as well. In style the text is remarkably clear and concise, free from pedantry, and easily intelligible to all who will have occasion to consult the book. The typography also is good, though a few slips have been allowed to pass.

ALBERT WILLIAMS, JR.

ALTERNATING CURRENTS: AN ANALYTICAL AND GRAPHICAL Treatment for Students and Engineers By Frederick Bedell, Ph. D., and Albert Curling Crehore, Ph. D. Second Edition. New York: The W. J. Johnston Co., Limited. London: Whittaker & Co., [Cloth. 8vo. 311 p. $2.50]

MESSRS. BEDELL AND CREHORE have been prolific writers upon the growing subject of alternating currents and their phenomena, and their articles had already gained them a reputation of the first rank in this important branch of electrics prior to the issue of the first edition of this book. While some of their contributions to current literature have shown them fully capable of handling the subject from a purely mathematical standpoint, others have shown them to be possessed of that rare quality of describing in simple terms the phenomena and reactions which are to the mathematician most easily explained by mathematical expressions not intelligible to others than those fully equipped in the higher mathematics. This second edition is almost an exact reproduction of the first necessitated by the early exhaustion of the latter, so that whatever is said of the edition under review will apply equally well to that which appeared earlier.

Part I of this work is devoted to an analytical treatment of the subject and Part II to a graphical treatment of the same problems. The idea which pervades the book seems to be to so arrange the results or conclusions reached, and the course of reasoning by which they were reached, that they may appeal separately to the reader or be taken in conjunction by the student who wishes to go into the development of the subject more minutely. The plan of giving two solutions to every problem—an analytical one and a graphical since, is also an admirable feature,—all minds are not equally susceptible to the same method of treatment.

The scope of the work is to start from the elementary principles of flow of periodic currents in simple circuits containing resistance and self-induction only, following this by a discussion of circuits containing resistance and capacity. Next comes the general case of circuits containing resistance, self-induction, and capacity, the question of the action of a condenser in circuit with self-induction, the cases of oscillatory and non-oscillatory charge and discharge, the neutralizing effects of self-induction and capacity, and the nature of wave-propagation in a conductor possessing self-induction and distributed capacity. Some of these subjects are illustrated by concrete examples which serve to elucidate much that would otherwise be abstruse and all of them, as before stated, are treated graphically in Part II.

One of the most attractive features of this work is the fact that it is practically self-contained. No one sufficiently equipped mathematically to read it at all will need to make reference to special mathematical treatises to enable him to follow the treatment presented. The book is certainly a model of its kind and a wide departure from the almost stereotyped mathematical treatise on the almost unavoidably mathematical subject of alternating-current phenomena.

But after all this is said we are compelled to make the inquiry *cui bono?* Mr. Charles Steinmetz, a mathematical as well as a practical electrician of international reputation and who has given especial attention to the phenomena under discussion, has recently declared that no two of the advanced mathematical theorists agree either with each other or with the facts, when discussing polyphase apparatus which involve the practical application of these theories—in a complicated form it is true, but nevertheless a practical application of these theories. It would seem probable, therefore, that these methamatical discussions in their elementary aspects must involve some false premises. As a mathematical divertisement the discussion of alternating currents is charming to the mathematician, and we freely admit that it has very largely advanced our knowledge of these most interesting phenomena. Mr. Steinmetz must admit this for he himself has used mathematics as a tool perhaps as much as any one engaged in this class of investigation and with the very best of results, but perhaps it is because mathematics has been with him a tool rather than a master that he has succeeded where others have failed.

NELSON W. PERRY.

STREET-RAILWAY MOTORS: WITH DESCRIPTIONS AND Cost of Plants and Operation of the Various Systems in Use or Proposed for Motive Power on Street Railways. By Herman Haupt, C E. Philadelphia: Henry Carey Baird & Co. [Cloth. 12mo. 213 p. $1.75.]

NOTWITHSTANDING the fact that the larger share of the street-railway mileage of the United States is to-day operated by electric power, and that the change from animal power to the new motor has practically been made within the past five or six years, it is quite evident that a large number of conservative engineers, and among them many whose opinions are by no means destitute of weight, are still disposed to consider the question of the most economical and efficient motor for street-railways—at least for municipalities furnishing a dense and heavy traffic—as one whose final solution has not yet been reached. In some instances the change from animal to electric power in an established street-railway system has been, beyond peradventure, a profitable one, but that in many other cases it has been quite otherwise is, unfortunately, equally true. As a matter of fact, the application of the electric motor to street-railway service, while far beyond its experimental stage in its relation to the traveling public, is by no means in the same advanced condition in its relations to the investors whose capital has been embarked in enterprises of this kind. The question therefore at once arises: "What are the conditions under which the electric railway is advantageous, and what are those under which it is not?" The work before us is an attempt to throw some light upon the subject of this inquiry, which at best is beset with numerous difficulties which to the practical railway-manager are sufficiently obvious.

The scope of the work is well indicated in the preface: "The object is simply to give results, with such simple explanations of principles as will be of interest and intelligible to practical men who may be called upon to contribute capital for construction, or to use their votes or influence in favor of any proposed system of rapid or local transit in cities." It is not too much to say that the author has succeeded admirably in that which he has undertaken to do. Separate chapters are devoted to horse-railroads, steam motors, cable traction, electric traction by trolley and storage, compressed-air, ammonia, hot-water, gas, and carbonic-acid motors. The fundamental principles of each plan are discussed, with brevity and yet with sufficient fullness, and the relative advantages and disadvantages pointed out with the impartiality which we have a right to expect from a veteran engineer. The most interesting and valuable part of the work, to most of those who will have occasion to consult its pages, will be the summary of the estimated cost of construction and operation of a typical street-railway under different systems. The line assumed is six miles of double track with a service at two-minute intervals. The estimates, in each case, are based upon the latest and most trustworthy statistics and returns available, the source of which is given in all cases where possible. An itemized statement of first cost as well as cost of maintenance and operation for each system is given, and the conclusion is reached, that for a line under the conditions named, the different systems rank as follows in the order of their relative economy: Compressed-air motors, overhead trolley, cable, gas motor, ammonia motor, steam motor, hot-water motor, and horse power.

The most striking feature of this exhibit is the unexpectedly favorable showing made by the compressed-air motor. While the author undoubtedly displays considerable partiality for this system, it is only fair to say that his partiality appears to be justified by the detailed facts and figures which he brings forward ; facts and figures which are not derived from theoretical assumptions, but from actual commercial practice for a considerable period of time. It would be out of place here to refer to the causes which appear to have conspired to keep the compressed-air motor in a position of obscurity and neglect, but it seems quite conclusive that these were wholly beside the question of the inherent merits of the system. The statistical information which General Haupt has here collected, evidently at the expense of much time and labor, cannot but be of great value to persons interested in street-railway property of any kind. It is rare indeed to find so much really useful material compressed into so small a compass.

FRANKLIN LEONARD POPE.

SEWAGE-DISPOSAL IN THE UNITED STATES. BY GEORGE W. Rafter, M. Am. Soc. C. E., and M. N. Baker, Ph. D., Associate Editor of the *Engineering News*. With plates and tables. New York : Van Nostrand. [Cloth. 4to. 589 p. $6.]

THIS almost cyclopedic work is an amplification of a former work by Mr. Baker —"Sewage-Purification in America—" which was reviewed in the October (1893) issue of this Magazine. It is really more than an amplification, and its scope is perhaps best shown by quoting from the preface : "In the fall of 1891 Mr. Rafter began, at the request of the publishers, the preparation of a manual of sewage-disposal in the United States. Early in 1892 Mr. Baker began the collection, largely by personal visits to existing purification-works, of data in regard to executed works as a basis for a series of articles in *Engineering News*. Neither was aware of the work of the other until about July 1, 1892, at which time Mr. Rafter had nearly completed the task to which he had set himself, while Mr. Baker was just beginning the series of articles on executed works which have since appeared in the journal named. A comparison of data indicated that Mr. Baker's work on the executed projects, by reason of bringing the information more nearly down to date, would add to the completeness of the book, and accordingly arrangements were made for joining forces. It addition to considerably extending Part II, Mr. Baker has also made material additions to Chapter VII in Part I, and has revised the whole work so far as necessary to include any additional information in his possession. This revision brings the work down to June, 1893."

The work is divided primarily into two parts. Part I is devoted mainly to a discussion of principles and Part II to descriptions of works. Both parts are well written but Part I will of necessity be of more permanent value than Part II. If all the principles involved in the subject were accurately known, Part I would never need revision. Unfortunately such is not the case, for our knowledge of the principles underlying the purification of sewage are, in some cases, quite vague and constantly undergoing change. Part II was a much easier task, but since the character of the works must necessarily undergo changes with our ideas of the principles upon which they were built, and with our knowledge of the value of methods, we see here quite as many causes for changes as in Part I.

As illustrating how rapidly these changes are going on we may cite two methods which are attracting the widest attention, though they seem not to have been more than slightly known by the authors as late as June, 1893.

The use of destructors for the combustion of the refuse and the utilization of the resulting heat for steam purposes, and the electrolytic method, by which sea-water or salt-water is made to give up a portion of its chlorin, which in turn is employed to oxidize the organic matter. The authors give but half a page to this latter (p. 563), and the description contains almost no data of value. For the past six months a process under another name, but apparently of the same kind, has attracted the widest attention abroad.

With occasional blemishes of the kind mentioned, and which are doubtless due to developments having been made so recently, the work is an excellent one and without doubt the most complete exposition extant of the present state of the rapidly-growing science of which it treats·

NELSON W. PERRY.

ART OF COPPERSMITHING. A PRACTICAL TREATISE ON Working Sheet Copper into all Forms. By John Fuller, Sr. New York: David Williams. [Cloth 8vo. 327 p. $3.]

RANKING second to silver in malleability and ductility, or third as compared with gold (the latter being the most malleable metal known), and ranking next to iron in tensile strength,—being also an abundant metal found native in some parts of the world, in which form its color is characteristic and conspicuous, while it often lies at or near the surface of the earth,—it seems that copper must have been one of the metals earliest known, worked, and valued in human industry. Certain it is that it was employed for many purposes in prehistoric times, and that its alloys with other metals, especially tin, were in common use at a date earlier than any existing record. Coupling this with the fact that the art of printing has accumulated vast libraries in which are stored treasures of information upon almost any subject or topic possible to make an object of study or research, the assertion of the publishers of this book on the art of coppersmithing, that it is the only volume in existence devoted to the subject, will be so surprising to most readers that some will be inclined, at first thought, to dispute the statement. But, testing it by a resort to extensive subject-catalogues wherein are indexed many books in which copper and copper-working are treated more or less broadly, or specially with reference to some particular art or industry, I am bound to say that I have been unable to find any treatise besides this that inclusively and integrally deals with the important, ancient, and interesting art of coppersmithing. Surely it is time that a book so long needed both by artisans and technical schools should be supplied.

Going carefully through the book from beginning to end the reader will be favorably impressed with the pleasant simplicity of the author's style. There has been no attempt at fine writing, but constant adherence to an evidently paramount purpose, which was to describe everything with absolute clearness. The writer says, in his preface : " I did my best to tell from my own experience, in the most lucid manner, that which is called for in every-day life in three separate branches of the copper trade, supposing with each lesson there was a good boy at my side." And he has so well executed the task that I doubt very much whether any other man living could have done it better. There are so many articles of copper illustrated and described in the book (there are 475 illustrations) that one is puzzled in making any attempt to select specimen passages; besides, in a work of this kind where nearly every part of the text is closely associated with and dependent upon one or more engravings, it would be necessary to reproduce these to make any characteristic part of the text available for such purpose. What can therefore be said here in addition to that already stated is, that the treatise seems to fully justify the claim of the author, that it is entirely practical, and of the publishers, that it is exhaustive; since few will be able to name any article made of sheet copper the practical construction of which, or of some strictly analogous article involving the same methods, is not fully and clearly described in the book, from the laying-out of patterns through all intermediate steps and processes to its final completion. The book is a much-needed and welcome addition to modern technical literature, and should at once be placed in every up-to-date trade-school and technical library.

LEICESTER ALLEN.

SURVEYING AND SURVEYING INSTRUMENTS. By G. A T. Middleton, Associate of the Royal Institute of British Architects, and Member of the Society of Architects; author of " Strains in Structures " and " House-Drainage." Illustrated. New York: Macmillan & Co. London: Whittaker & Co. [Cloth. 8vo. 112 p. $1.25.]

THIS little book, the latest of the " specialists' series," is a compilation of a series of articles by the author that previously appeared in the *Building News*. The first chapter is entitled " surveys with chain only." No engineer who has had a training in surveying without instruments will undervalue this chapter. In fact our own belief, which comes from experience, is that a thorough training in surveying without instruments other than a prismatic compass, and perhaps a chain, is one of the most valuable branches of instruction that can be taught to the student in engineering. The chapter is well written, but might be extended so as to include surveying without the chain as well. The author sticks to the Gunter's-line chain. This has been practically abandoned in this country for the steel tape, which is also mentioned in this chapter, but not favorably.

Chapter II is devoted to instructions as to how to pass obstructions,—the methods being essentially those employed in this country. The author introduces here, however, the use of right-angle instruments—the optical square and Weldon's right-angle prism. In similar work in this country the prismatic compass is more used and has a much wider range of usefulness since not only right-angles but any other angles can be measured thereby. It, would therefore, seem that, if this work is a reflection of the practice abroad, the instruction in our best engineering schools is far ahead of that usual in England.

The succeeding chapters are devoted to "the uses of the level," "various forms of level and their adjustment," "the use of angle-measuring instruments," "the theodolite and other angle measuring-instruments," and "instruments for ascertaining distances."

Looking at this book more as an index of English practice than as a text-book,—for as the latter it could not be considered in this country,—we are struck with what appears to be an adherence to antiquated instruments and methods. For instance, an amount of space is devoted to the theodolite wholly out of proportion to the importance of that instrument with us, and the plane table is not mentioned at all. In conclusion it may be said that the latter part of the book partakes much of the nature of an advertisement of several instrument-makers to whom the author acknowledges his indebtedness for the instruments loaned for the purpose of preparing the illustrations used.

NELSON W. PERRY.

GAS-LIGHTING AND GAS-FITTING, INCLUDING SPECIFICATIONS and Rules for Gas-Piping, Notes on the Advantages of Gas for Cooking and Heating, and Useful Hints to Gas-Consumers. A Pocket-Book for Gas Companies, Gas Engineers and Gas-Fitters, for Manufacturers of Gas-Fixtures and Dealers in Gas Appliances, for Gas-Consumers, Architects and Builders, Health Officers, and Sanitary Inspectors. Second Edition. By William Paul Gerhard, C. E., Consulting Engineer for Sanitary Works, New York City. New York: Van Nostrand. [Boards. 12mo. 188 p. 50 cents.]

THIS work forms one of the Van Nostrand Science Series. The chief headings are "artificial illumination," "historical notes on gas-lighting," and on the "advantages of gas," "gas for cooking and heating purposes," "hints to gas-consumers on the proper use and management of gas," and the "rules and regulations on gas" issued by the municipal department of the city of Munich. The matter under each of these headings will have especial interest to a separate class of readers. That which will probably interest the largest circle of readers will be found under the head of "hints to gas-consumers on the proper use and management of gas." Under this head is given a very large amount of information which every user of gas should know but which most of them do not know. It is a fact that a very large portion of the consumption of gas is unnecessary for the best results and due to ignorance of simple facts and precautions, which, if known and observed, would greatly reduce the gas-bills which confront us every month. This little brochure seems to be a most excellent presentation of the subject and will be found useful to the classes of readers for which it is intended.

NEW BOOKS OF THE MONTH.

Asutosh, Mukhopadhyay=An Elementary Treatise on the Geometry of Conics. New York: Macmillan. [Cloth. 12mo. 184 p. $1.10, net.]

Beatty, J.=McKinleyism as It Appears to a Non-partisan. Columbus, Ohio: A. H. Smythe. [Cloth. 12mo. 156 p. $1.]

Bevan, D., and Coplin, W. M. L.=A Manual of Practical Hygiene. Designed for sanitary and health officers, practitioners, and students of medicine, with an introduction by H. A. Hare. Illustrated. Philadelphia: Blakiston. [Cloth. 8vo. 456 p. $4.]

Bigelow, J. J.=The Principles of Strategy. Illustrated mainly from American campaigns. Philadelphia: Lippincott. [Cloth. 8vo. 362 p., maps. $5.]

Bolles, Albert S.—The Bankers' Almanac and Register and Legal Directory for 1894. Forty-fourth year. New York: Macmillan. [Cloth. 8vo. 422 p. $3.50, net.]

Burr, F. M.=Life and Works of Alexander Anderson, M. D., the first American Wood-Engraver. Illustrated with three portraits of Dr. Anderson, and over 30 engravings by himself. New York: Burr Brothers. [Half Russia. 8vo. 3-210 p. $4.]

Cogley, T. S.=The Law of Strikes, Lockouts, and Labor Organizations. Washington: Lowdermilk. [Sheep. 8vo. 14-377 p. $4.]

Coxe, Brinton.—An Essay on Judicial Power, and Unconstitutional Legislation. Being a commentary on parts of the constitution of the United States. Philadelphia: Kay & Brothers. [Cloth. 8vo 16–415 p. $3.]

Davis, W. Morris.=Elementry Meteorology. Illustrated. Boston: Ginn & Co. [Cloth. 8vo. 12–355 p. $2.70.]

Dawson, Sir J. W.=The Canadian Ice Age. Being notes on the pleistocene geology of Canada; with special reference to the life of the period, and to its climatal conditions. New York: Scientific Publishing Co. [Cloth. 12mo. 301 p. $2.]

Denning, D.=Wood Carving for Amateurs. Second revised and analyzed edition. New York: Spon & Chamberlain [Paper. 12mo. 80 p. 40 cents.]

Dogs (The) and the Fleas, by One of the Dogs. A political and social satire. Illustrated. Chicago: Douglas McCallum. [Cloth. 16mo. 2–273 p. $1.]

Edwards, Emory.=Nine Hundred Examination Questions and Answers for Engineers and Firemen (stationary and marine), who desire to obtain a United States government or state license. New edition. Philadelphia: H. Carey Baird & Co. [Pocket-book form. 16mo. 240 p. $1.50.]

Edwards, Joseph F., *M. D.*=Edwards's Catechism of Hygiene. For use in schools. Atlantic City, N. J.: The Author. [Cloth. 16mo. 3–109 p. 40 cents.]

Fahie, A.=House-Lighting by Electricity. New York: Spon & Chamberlain. [Cloth. 8vo. 80 p. 80 cts.]

Gage, Simon H.=The Microscope and Microscopical Methods. Fifth and Revised edition. Illustrated. (Part I of the Microscope and Histology.) Ithaca, N. Y.: Comstock Publishing Co. [Cloth. 8vo. 7–165 p. $1.50.]

Glazebrook, R. T.=Heat. An elementary text-book, theoretical and practical, for colleges and schools. (Cambridge natural science manuals, physical series.) New York: Macmillan. [Cloth. 12mo. 230 p. $1, net.]

Greaves, J.=A Treatise on Elementary Hydrostatics. New York: Macmillan. [Cloth. 12mo. 204 p. $10, net.]

Hall, E. H., and Bergan, J. Y. Jr.=A Key to "Text Book of Physics." New York: Henry Holt & Co. [Flexible cloth. 12mo. 50 cents, net.]

NEW TRADE CATALOGUES.

Any of these catalogues free on application to the manufacturers.

The Troy Laundry Machine Company, Troy, N. Y.=Laundry Machinery and Laundry Supplies. 116 p.

Electric Appliance Company, Chicago.=Electric Light, Power, Railway, and House Goods Supplies. 244 p. [Complete, compact, and convenient for reference.]

The Deming Company, Salem, Ohio.=Iron and Brass Pumps for Hand Mill and Power, Hydraulic Rams, Artesian Well Brass Cylinders, Pump Fixtures, Well Tools and Supplies. 230 p., bound.

Darner & Dutton, Cleveland, Ohio.=Motors and Trail Car Trucks. 30 p. [Street-car wheels and axles, turn-tables, motor gears and pinions, castings, etc.]

National Electric Manufacturing Company, Eau Claire, Wis.=Alternating and Direct Current Apparatus. 71 p. [Multipolar power generators and motors, transformers of any capacity, and all electrical appliances.]

Bramwell Car Company, St. Louis, Mo.=The Accelerator Car. [Greater capacity, quicker time.]

The Brush Electric Company, Cleveland, Ohio.=The Brush Arc Dynamo. 50 p. [Brush arc-lighting apparatus, etc.]

The Brush Electric Company, Cleveland, Ohio.=The Brush Electric Lamp. 30 p.

The Bennett & Peck Heating and Ventilating Company, Cincinnati, Ohio.=The True Principles of Warming and Ventilating as Applied to Schools, Churches, Public Buildings, and Dwellings; Improved Sanitary Dry and Flush Closets. 80 p. [Latest improvements in apparatus.]

The Steam Stone Cutter Company, Rutland, Vt.=Circular Descriptive of the Wardwell Stone Channeling and Quarrying Machines. 18 p.

The American Fire Engine Company, Seneca Falls, N. Y.=Piston and Rotary Steam Fire Engines. 112 p. [Hose carriages, carts, pumps for fire-boats, heaters for engine-houses, fire-department supplies, etc.]

Electric Engineering and Supply Company, Syracuse, N. Y.=Electric Light and Railway Supplies for All Systems. 140 p.

McGuire Manufacturing Company, Chicago.=Patented Electric Cable and Elevated Railroad Trucks. 60 p.

Kalamazoo Railroad Velocipede Car Company, Kalamazoo, Mich.=Steel Velocipede Cars. 35 p. [Steel-wheeled hand-cars, steam inspection cars, sugar-cane cars, etc.]

American Battery Company, Chicago.=The American Storage Battery for Light and Power. 30 p.

William Sellers & Co., Philadelphia.=Hydraulic Testing Machines. System of A. H. Emery, C. E. 14 p.

Hartman Sliding Blind Company, Crestline O.=Hartman's Patent Inside Sliding Window Blinds. 95 p.

THE

ENGINEERING MAGAZINE

VOL. VII. JUNE, 1894. No. 3

THE COXEY CRUSADE AND ITS MEANING.

A MENACE TO REPUBLICAN INSTITUTIONS.

By William Nelson Black.

"OH! Coxey is a lunatic," exclaims the industrial operator engaged contentedly in the prosecution of his work; "you do not propose to discuss the peregrinations of this cross-country tramp through the dignified pages of an engineering magazine?"

But Coxey is the representative—a somewhat exaggerated representative it may be—of a class determined upon the humiliation, if not the spoliation, of every industrial worker who has become an employer of labor; and we cannot afford to ignore his peregrinations merely because he has chosen to put on an antic disposition. He differs but little, after all, from the men who have elevated his flag in the senate of the United States, and the whole party of Populists, State Socialists, and paternalists of both the old political parties could very consistently be training at his heels. He is a clear-cut representative of an old foe of popular liberties which is masquerading under new names, and he is hardly the less dangerous because he represents a minority, comparatively insignificant, of the total population of the country. Under our scheme of universal suffrage, or possibly under any scheme of self or representative government that could be devised, the factions holding the balance of power, composed generally of the most illogical and narrowly-trained members of the community, are able to impress themselves on the public policy to a degree far beyond the warrant of their numerical strength or merits. Have we not seen the Democratic party almost rent in twain in an effort at surrendering its identity and occupying ground directly opposed to its tenets for the purpose of catching the Coxey contingent, or the faction of which Coxey is the most distinguished representative? Then it would be exceedingly un-

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wise to say that any political manifestation should be ignored because it is seemingly insignificant.

It may be said, however, that these are subjects for discussion in political journals or among political philosophers, and that they do not directly concern the hard-headed practical men engaged in industrial and other economic pursuits, to whom these pages are devoted. But this would be wrong again. Have we not recently seen the Coxey contingent at work even in the metropolitan city of New York? There is an industrial organization in New York engaged in furnishing rapid transit to the city. It furnishes better rapid transit than any other corresponding organization in the world, and it is better prepared to furnish improved rapid transit, if it could only be permitted, than any other agency. Yet we see an attempt made to knock it out with a municipal bludgeon in the shape of a proposal that the city shall build a system of underground railways. Even the New York Chamber of Commerce, a body of merchants who have lent themselves to the scheme, could very properly be organized into a militant company for the Coxey brigade, and, under the captaincy of the respected citizen whose fitness for command will be universally conceded, sent out to battle in behalf of the plans which Coxey is endeavoring to promote. It will not do to say, therefore, that Coxey is a personage of no importance to practical men. They are the only men whom he does vitally concern; and he is all the more dangerous to their interests because, partly on account of absorption in their pursuits and partly because of their lack of comprehension of the danger, they permit themselves to remain apathetic.

What is the significance of this Coxey crusade? As to Coxey personally, there will be little difficulty in sketching his most prominent features. He is simply a man with an unballasted head, an adventurer who has made war on the United States government and constitution, unwittingly. The mouth of this American Don Quixote has been as full of peaceful professions as the mouth of a German kaiser or Russian czar; but his organization, it will be observed, is military, and it is fair to presume that every recruit in his ranks able to buy, beg, or borrow a weapon is armed. But it is not probable that there is coherency enough in his head to enable him to comprehend his attitude. He is simply a social freak, and is hardly to be called a promoter of civil war. And in attempting to analyze the Coxey crusade we find ourselves carried at once into the commonplaces of history. Coxey planned his invasion of Washington to compel the federal government to build some new and better roads. We see, therefore, that the scheme is comprehensive. The New York Chamber of Commerce has recently invaded Albany to compel the state of New York, through its municipal agent seated on Manhattan island, to engage in a precisely corresponding enterprise. But the suggestion raises historical reminiscences. The Roman empire was a great road-builder in its day; and now that the fact must be recalled, we are reminded that the United States, in the earlier days of their career, built a few roads, and they might have continued at the work to this day had it not been discovered that it was hardly a constitutional field for the exercise of functions created for the protection of life and property. We are a commonplace people in the United States, and do not take kindly to the magnificent and helpful conceptions of governmental paternalism. Yet we have managed to build, during the last fifty years, about 200,000 miles of incomparably better roads than the Roman empire ever conceived, and will build several million more miles of a corresponding kind, and by corresponding processes, during the fifty years to come. Road-building is the great engineering and industrial specialty in the United States; but the kind of roads that we want—railroads—never enters into the conceptions of the tramp, and the truly republican expedients for their construction seem to be something entirely beyond his comprehension.

The truth about Coxey is that he is a representative of much more than he imagines, but a representative who does not comprehend his own constituents or understand the cause that he is trying to serve. All over the world, where men are sufficiently enlightened to know their own capabilities and rights, imperialism, the other name for paternalism, is at its last gasp. But it is trying as it never tried before to convince men that it may be useful if they will only lend it enough of their substance to give it the ability to work in their behalf. Forgetful of the fact that all manly men prefer working in their own behalf, this seems to be the prevailing inspiration in the new propaganda of imperialism; and hence, in chief part, though military considerations and depleted exchequers are not without powerful influence, those government railways and telegraphic lines that cross and recross the leading continental countries of Europe. Hence, also, the craze for a corresponding absorption by government of industrial functions in England, for the Englishman is generally a very sensible being until you touch upon the permanency of the monarchy, and then he becomes as erratic as any Don Quixote. All his efforts looking to enlargement of municipal powers by the invasion of industrial fields, and all his longing for government possession of the railways, are really inspired by dread of the revolutionary elements that alarm the higher and middle classes, and keep the ground continually trembling underneath the throne. True this is not the ostensible plea for the efforts at strengthening the resources of government; but it is the only logical plea that could be made, and we need not trouble ourselves about anything ostensible if it is upheld in defiance of logic. The whole brood of State Socialists in Europe, of whom Coxey may be called an American representative, were fashioned in an imperialistic mold; and, however viciously they may kick against the service to which they are assigned, they may be sure that they will be made component parts of a regal edifice.

Men must not for a moment imagine that there is anything new in what is known as Populism in this country and State Socialism in Europe. Sixty millions of peasantry in Russia, with hardly intelligence enough to keep them from starvation, are living, as possibly their ancestors for a thousand years have lived, on lands held by substantially the same tenure advocated by Henry George in his "Progress and Poverty"; and, had Edward Bellamy only looked backward in his dream as far as the declining days of the Roman empire, he might have paused by the way and seen Mahomet II knocking down the gates of Constantinople in order that he might extinguish a nation that had found so many Bellamys among its statesmen that it had become too much enervated and too worthless to live. State Socialism is old. It is even prehistoric in its antiquity and dates certainly from the cave-dwellers. Civilization is its antithesis.

In treating of Coxey and his hosts, however, it will not be necessary to go very deeply into historical research. A mere glance at the past will serve to show that Populism can neither create nor preserve a great nation, and the best field for illustration will be found among the people who have built up from the wilderness within a hundred years the most powerful nation on earth. Even the enemies of the United States cannot deny that they have done wonders. But they will ascribe the rapidity of our advance to wrong causes. They will first credit it to our expansive territory. But other nations that remain comparatively insignificant have as much territory as the American Union. England herself holds three or four times as much, and Russia, hardly yet civilized beyond a few millions of her hundred million inhabitants, has vastly more. It cannot then be our expansive territory that has given us the lead. But they will ascribe it, also, to immigration. We have drawn immigrants, however, only because we offered employment, and, everything considered, our advance was quite as rapid during the first decade of our history, before any considerable immigration began, as it has been during the last decade. Between the close of the revolutionary war and the beginning of the second war with England, a period of about twenty-five years, our population rose from less than three millions to over nine millions. We have the right to claim, therefore, that our rapid advance to the leading material position among the nations of the world has been due, and exclusively due, to our political and social policy. Then what has been this policy? By understanding it and pursuing it we may best secure the future.

Henry George, Edward Bellamy, and even Coxey himself must be forgotten here, and something said for Thomas Jefferson. The beginning of the American revolution marked a new era in the political history of the world. Down to the date of the Declaration of Independence the true functions of government had never been clearly formulated. In a chaotic or nebulous condition the principles enunciated in that declaration of rights permeated English society, and modified the British constitution; but the limitations of government and its true purposes were in no country clearly understood. Political authority in all countries, wielded by sovereigns or parliaments, or by sovereigns and parliaments acting together, might have been defined in terms not unlike the terms selected by Madame De Stael for describing the government of Russia. It was an absolute despotism tempered by the fear of revolution. There were no reserved rights for the unofficial classes. There was absolutely no limit to the powers exercised by the heads of the state except the boundaries erected by expediency; and to be king implied the exercise of any authority that did not endanger the crown. There would have been halcyon days for Coxey when George the Third was king. If not hanged for his impudence, he could have presented his petition with boots on to the two houses of parliament or to the king himself, and if it was not granted it would not have been because of constitutional obstructions.

But while this was the conception of political power in Europe, the conditions for change were preparing in America. Along the borders of a wilderness, far removed from courts and camps, a hardy race grew up to some numerical strength, and these men, unfamiliar with the burly figure of a tipstaff at every turn, soon discovered that "that government is best which governs least," and yet serves the purposes of government. In the wilderness they learned to plow when the field was fallow, to put in the sickle when the harvest was ripe, and to protect themselves betime with their own right arms when forced to submit to savage invasion. In short, they learned how much men could do to help themselves when left to their own resources; and hence, finally, a new code of social precepts, a Declaration of Independence, and, in the end, a new constitution to embody permanently in a political organism the principles by which they were controlled. They were principles, too, which will be applicable forever, or until a still higher evolution of the race permits a yet longer stride in the direction of the complete enfranchisement of the individual. Men in America have been taught that it is not only their privilege, but their duty, to act in their own behalf, and that they themselves, individually, and not the governing classes, whether elective or hereditary, form the constituents of society. This is our code, and it has been due to the general acceptance of such tenets that the United States have advanced so rapidly, while the nations of Europe, handicapped by their lumbering political machinery, and enfeebled by its weight, though advancing, have moved at a snail's pace, and are compelled to see avalanches of the best elements of their population departing annually for the less obstructed soil of the American union. Consider for a moment what Russia would be to-day if, in place of her state socialistic system of land-tenure and her few thousand miles of government railways, built chiefly for the transportation of soldiers, she had free lands and 200,000 miles of railways built, owned, and operated like the railways of the United States! Emigration would be moving eastward rather than westward, and not only all Russia herself, but the waste places of southern Siberia would be covered by a teeming and energetic population.

It will be necessary, however, to take leave of Thomas Jefferson and his policy and to come back to Coxey. The cohorts of this new order of generalissimo, reinforced, metaphorically at least, by the New York Chamber of Commerce, have been invading the steps of the capitol, and we must try to comprehend the meaning of the assault. Does it mean that any considerable proportion of the American people are prepared to abandon the political ideas that were formulated when the Union was formed, and return to the ideas that obtained under the rule of the Georges? Or does it mean that a considerable number of our people, discouraged by the riotous spirit of the times, have come to the conclusion that our ideas of government need stiffening a little—just enough to enable us to deal more sternly with the disorderly elements—and that they are willing to humor the cranks for their own semi-revolutionary purposes? No, it is not to be conceived that either of these questions can be answered in the affirmative. No country handles the disorderly elements so successfully as the United States, and we must find some other cause for the apparent changes in public opinion. We shall find it, it is to be feared, in ignorance,—a most discouraging reflection after all the expenditures that have been made for the support of our public schools. But it may be possible that our public-school teachers have spent so much time in extolling the heroic character of the revolutionary leaders that they have forgotten to teach what those leaders represented; and, if this be true, it would be best to follow the example of the time when a history of the United States was the only school-reader in use, and when every pupil was forced to read aloud a passage from the national records each morning before proceeding to his more laborious studies. The history of the United States may not be a very good book for teaching the accomplishments of elocution, but while it was in daily use among the rising generation we were growing continually further and further away from Coxeyism and all that this remarkable leader represents.

But, after all, this is a poor country for both cranks and fools. True, it has seemed for a few years past as if they held some sort of congenital relation to the soil, and that it was highly fertilized to promote their increase. The crop has been certainly redundant, but, while they have played some curious antics with our laws, they have hardly yet made an appreciable impression on our institutions. The country is generally directed in the end by its men of ability and training. But the cranks are giving us a hard time. This much must be conceded ; and there is reason to feel a little impatience for a return of the day when men were taught that work was something to be done by themselves individually and not by government, and that it is better to work under a " boss " than under a slave-driver. In short, as Congressman M. D. Harter has very aptly said, what is needed just now is to " publish far and wide that it is not the business of the United States to raise prices, provide work, regulate wages, or in any way to interfere in the private business or personal affairs of the people. If we go on in the mad chase after prosperity, under the leadership of the Coxeys, McKinleys, Stewarts, Peffers, Blands, Hatches, etc., we will find harder times and greater suffering ahead of us. The troubles we are having are the outgrowth of simon-pure paternalism. Our country, with all its magnificent resources, is still here ; our people have not lost their skill ; and we can be as prosperous and happy as ever, if we demand equal laws and a sound currency from the government, and then work out our own salvation."

AMERICAN ARCHITECTURE THROUGH ENGLISH SPECTACLES.

By Banister F. Fletcher, A. R. I. B. A.

TO a European the study of the progress of architecture in a new country and under conditions which do not obtain in the old world must be exceedingly interesting, and, provided the criticism be undertaken with sufficient open-mindedness and not too much insular prejudice, I take it that the result of the investigation should be of interest to the American architect.

My tour commenced with New York, whence I went to Philadelphia, Baltimore, and Washington, across to Chicago, and back through Canada to Boston and New York. This, done somewhat thoroughly, would, I am given to understand, give one a very good idea of the more important buildings and the general methods of architectural practice. The influence of ancient styles still seems to hold remarkable sway, especially in some of the more important buildings, but, as far as one can see, with the exception of some particular works by a prominent firm of New York architects, the influence of style (as we understand it) seems to be on the wane and there seems to be a general breaking away from precedent. Of course in many cases this is due rather more to ignorance than to any desire to be original for originality's sake.

It is hardly possible to speak of American architecture without reference to the training of the architect himself. Most of the leading architects, with a few brilliant exceptions, appear to have received their preliminary training at the École des Beaux-Arts at Paris, and there is no doubt that (although in England we despise it because it is not English) it is a capital training in the classic manner, and also in style and composition. Oddly enough, the training seems peculiarly suited to the American because he forgets it, for in the great majority of cases he wisely lays aside the strict classic forms and ideas and, always aided by having had a thorough grinding in the principles of his art, he sets forth bent on solving new problems in a new way, and does not seem to be bound down by any of the obsolete rules of the studio.

In respect of new problems, new wants, and new difficulties to be overcome, the American has a great advantage in that he has to solve them in a new way and therefore should not fail to be able to present new forms, while we over here generally have to design buildings which are to be used for the same purpose as hundreds of others, and yet we are expected to do something strikingly original, which, if done, is usually very bad.

In domestic architecture we may see at once some very original work, treated in a manner which is picturesque and suitable to modern needs. We might divide this heading into monumental work and purely domestic work. In the former class we must of course classify Mr. Richard M. Hunt's important country works. Now Mr. Hunt is French, "quite French," even more so than any of his fellow-architects who have studied at the École, and perhaps in consequence of his more prolonged residence there. I was fortunate in seeing some of his work at Newport, but found nothing very remarkable in his house for Mr. Goelet, the exterior being conceived in the Henri II style, and rather hard in treatment. It is far more satisfactory in the interior, with a fine staircase, somewhat later in style, and executed in Caen stone. The details of this staircase and the hall generally are very carefully worked out, and the workmanship of the stonework generally reflects great credit on the masons employed. The method of bringing over mantelpieces and ceiling paintings from France or Italy is surely the owner's caprice, and is not conducive to the progress of architecture, however good the articles in question may be.

On a more ambitious scale is the château Mr. Hunt is building for Mr. George W. Vanderbilt in North Carolina. From what the architect showed me of the plans and model I should say that this is one of the most extensive architectural conceptions of modern days; he has had the coöperation of Mr. Olmsted, the landscape architect, as to the general disposition of the grounds surrounding the house. The whole scheme seems laid out on a most grandiose scale, regardless of expense, and has given Mr. Hunt an opportunity that can rarely occur to an architect, of giving him the full play of his fancy and experience. The design is based on the old châteaux of Chambord, Chenonceaux, Blois, etc., and the scheme bids fair to be one of the most successful of any age. It will be interesting as a comparison with our Blenheim Palace by Sir John Vanbrugh, the largest and most extravagant of palaces in England, to the character of whose architecture Pope sarcastically referred on the architect's death:

> "Lie heavy on him Earth, for he
> Laid many a heavy load on thee."

Before proceeding to the purely domestic side, we might remark on the lavish expenditure on their houses by rich Americans. Of course we must allow for the higher price of labor in the States, but even then a man seems to spend £50,000 where over here he would spend half or even less. Mr. George B. Post's work for Mr. Cornelius Vanderbilt, which he kindly showed me over, shows considerable skill in planning and adaptation to modern requirements, although rather too French to suit our insular ideas.

It is with great delight and satisfaction that I approach the country houses by Messrs. Peabody and Stearns at Newport, R. I., and the more so because of the fact that I believe Mr. Peabody did not study in Paris, but in England, in the office of Mr. Alfred Waterhouse, R. A. Here indeed we have food for reflection and here indeed we have architecture in its truest and widest sense. In two of the houses which I visited in company with Mr. Peabody, and which are situated on a rocky prominence overlooking the bay, one really felt as if one were in a new country where new ideas were being given full play without regard to rusty formulæ or pedantic precedent, where designing was done with a love for the work and a sympathy with the objects of the design and of the materials at hand which we, in an old country saturated with "old examples," can hardly hope to attain. The houses, especially one of them, seem to rise so naturally and so gracefully out of the rugged rock foundation as to be part almost of the soil, the lower story being built of a rough bluish granite in thin courses and large open joints (the mortar being kept back from the face for the purposes of effect) which give a texture to the face; gradually as we get higher in the composition the roughness changes to the more polished surface of wood and shingle. The plan, too, with its spacious hall and ample staircase, seems to tell us, but in a fresh manner, that the wants of the modern American are not unlike those of his Elizabethan ancestor. The only point in the house which would not be found in the sixteenth century is the spacious roofed piazza, curving around into the promontory, and from which an extended view of the bay can be obtained.

Another interesting specimen of these architects' work, which, without any affectation whatever, made one think of an old English homestead, was a group of houses, set back from the road, with an open "green" in front, fringed with a low stone wall, in which all the elements of subdued and self-restrained design, so characteristic of our own "old work," are present. Perhaps nothing else during my stay in America gave me so much pleasure as this quiet domestic work of Messrs. Peabody and Stearns.

Of the wooden or frame houses of which so many exist in America there seems not much to say, except that they lose in trying to be too much, being crowded with features, but it must be owned that in several instances, presumably where architects have been employed, they are at least satisfactory. The influence of Richardson, too, is painfully apparent in old and hackneyed features, for the old low semi-circular entrance has surely had its day. Why is it necessary to use it everywhere, from the humblest cottage to the most pretentious mansion? Truly a master in architecture (as Richardson undoubtedly was) has much to answer for when he seems to have the power of hypnotizing fellow-architects into copying his most ordinary features.

On the less ambitious domestic architecture in towns there is some very good work in the States; in Chicago, for instance, on Michigan avenue there are some houses inspired by Richardson, but at the same time exhibiting a certain freshness of design that is noteworthy. In the suburbs of Brooklyn I was particularly charmed by some houses, designed and elegantly fitted in a style somewhat resembling our own domestic work of the same type and cast in the same groove as the work of the late John D. Sedding, with large flat surfaces, the ornamentation massed at points to form contrast. The ugly stoop of the pattern-book Brooklyn house was, in these houses, made a feature, being treated in a novel way by side entrances, which helped to break the dull monotony of a Brooklyn street.

In civic architecture I enter on a section which has filled me with wonder and amazement. Philadelphia! O Philadelphia! the ancestral city of the antique Britisher, the home of cricket and other British sports: why wast thou built thus rudely to show thy face to a descendant?—thyself being in the rear, the very rearguard of American architecture! One can hardly believe that in any one city in the world there are crowded so many monstrosities in the way of architectural design as in Philadelphia, and yet one has one's reward in visiting the place, for in the work of some of the younger men especially there is good material. I would refer to Mr. F. Miles Day and Mr. Wilson Eyre, both of whose work is fresh and full of true artistic feeling. The Art Club, by the former, is a somewhat pure type of early French Renaissance and stands as an oasis in a desert of bad work, and there are two or three other works by the same architects noticeable for freshness of taste and inventiveness in design. But ye architectural student in search of novel treatment, I pray thee, visit not the University!

From Pennsylvania to Chicago is a far cry, in regard both to distance and to architecture. My first impression of the tall building did not overwhelm me as much as I expected. In the first place, I do not belong to the school of architects (in reality, antiquaries) who dislike tall buildings because they are tall buildings, but rather to the school which, being bound to admit the necessity of the case, would endeavor to so carry out the design as to incorporate true principles of art. Now the Chicagoans have decided that they want tall buildings, that they must have tall buildings; therefore it behooves the Chicago architect to cope with this new problem of design and construction as architects did in the olden days when architecture was a progressive art and when everybody did his best in that state of architecture in which he was called.

Can you imagine a medieval architect (or master-builder, or chief workman, whichever he styled himself) uttering his laments and casting up his eyes to heaven when his lord told him that he was tired of sleeping in the common hall in the midst of his retainers and that he must have a "solar,"—yes, a private sleeping chamber for himself and wife!—thus starting all the development of domestic plan? What would the modern antiquarian-architect have said? Why this: "I can see no precedent for a private-sleeping chamber; your father had none and it would spoil the symmetry of your old Norman keep if I tack on chambers, with drawing-rooms and offices!" But the architect did no such thing; he had to fulfil conditions as we do and did it, as we should do, taking a delight in his work. And so, as tall buildings are a product of the age, let us glance at how the most successful designs are carried out.

It would appear, in the first instance, as if the cardinal principle to be adopted in designing a building would be to make it appear what it really is, namely, *one* building, or, in other words, to follow up the principle of *unity*. It was one of the greatest principles insisted on by the Greeks, this one of unity,—variety *in* unity, if you will, but you must have unity. Now this is *not* to be obtained by laying one floor on another with strongly-marked horizontal lines, as we note in some of the designs produced for these buildings, but in applying the same *principle* as the Greeks did to their one-story buildings.

The classic column is primarily suggestive of unity in both expression and purpose; with its entablature complete, we can take away none of the parts without spoiling the whole. Apply the same principle to a tall building, and what do we get? Firstly, a base,—the lower one, two, or three stories (according to the height of the whole composition) bound together by strong horizontal lines corresponding to the molding on the base of your classic column; then come the next ten or twelve stories, which should be treated plainly, corresponding to the fluted shaft of our column; next the upper stories, answering to the capital of the column with projecting cornice and binding horizontal lines. In what building do we find these principles carried out? In the Schiller Theater, by Messrs. Adler & Sullivan. This building appeals at once to me as being the best designed tall structure, not only in Chicago, but in the States. The architects, by a clever manipulation of the front, have made the central part what it really is, what every tall building is more or less,—*i. e.*, a tower;

by keeping down the end portions and letting the central part disengage itself above them, it freely expresses itself. The two lower stories of the whole façade are bound together, as they should be, by strong horizontal lines, emphasized in this case by a happily proportioned projecting balcony, which, with the deep shadow it casts, aids the horizontal effect to be aimed at in these lower stories ; then follow the ten or twelve stories (I forget how many), corresponding to the shaft of our classic column, the windows recessed, as it were, in the hollows of the flutes and plainly treated. The tops of the piers are connected by arches, without moldings or pseudo-capitals,—in fact, as the arrises between the flutes in our classic column ; and the remaining stories are tied well together by horizontal moldings and crowned by the overhanging abacus of our capital or cornice. I take it, in fact, that the Schiller Theater is in the same relation to the new style of tall building as the Parthenon bears to the architecture of Greece.

Among other tall buildings which appeared to me worthy of notice was the Monadnock building, by Messrs. Burnham and Root, in which slight projecting bays are worked into the design ; the rounding of the angles in the building is peculiar, but need not be repeated. The great charm of the building is its simplicity, and I would suggest to every one designing a building of this size to "let it alone" and allow it to tell its tale by its boldness of mass and proportion, and not to fritter away the dignity which size can give by an unlimited and totally unnecessary crowding in of small detail. I mention this because there seems a tendency in this direction, especially where terra-cotta, which is so easily cast into molds, has been employed. The Masonic Temple, by Messrs. Burnham and Root, is another building in which the vertical principle is well maintained. In the arrangement or plan it is calculated to "give pause" to any benighted Britisher. Fancy entering a building in London and, after passing through a vestibule and hall fitted with well-designed iron-work and lined with marbles, coming upon an array of fourteen elevators arranged in a semicircular plan, each under the charge of a guard and with a head-guard over all sending these vertical-train loads of people "on time" express to such or such a floor, or calling at all floors up No. so and so.

The lift (I should say "elevator") fittings generally in the States I found to be excellent, in both design and execution, and our English designers might learn a good many lessons in the way they are fitted up, especially in the iron or copper screens with which they are enclosed. The internal fittings of the Auditorium building struck me as being exceptionally well carried out, more especially in the restaurant, where stamped and burnished copper as a covering to the columns, etc., are carried out in excellent design.

A word or two as to church architecture. I am bound to say I was disappointed with a good deal of what I saw. Richardson's masterpiece in Boston is no doubt fine in its general conception, especially if we remember when it was done, and more, it is adapted to the modern preacher in America, where the sermon takes such an important place in the service. The stained glass, however, which should have been used sparingly, having regard to the size of the windows and the style of the building, has been much over-done, for the interior, even on a bright day, is in semi-darkness.

I was very pleased with the bold, rich effect of Richardson's work at Harvard University. The effect of Richardson's individuality on church work has, I should say, been enormous, although I was perhaps unfortunate in not seeing any specially fine churches; but I am convinced from what I have seen in the way of drawings and photographs that there is a great future for American ecclesiastical work. As a type which will perhaps be understood, I may mention a Presbyterian church near Cincinnati, by Mr. Martin Aitken, as being Romanesque in feeling and yet imbued with considerable freshness of design. The church of St. Agnes in New York, by Mr. W. A. Potter, contains some elaborate marble and mosaic fittings, reminding one at once of the church of San Clemente at Rome and of the cloisters of St. John Lateran, and quite equal to the latter in execution, reflecting great credit not only on the architect but on the liberal-minded policy of his clients.

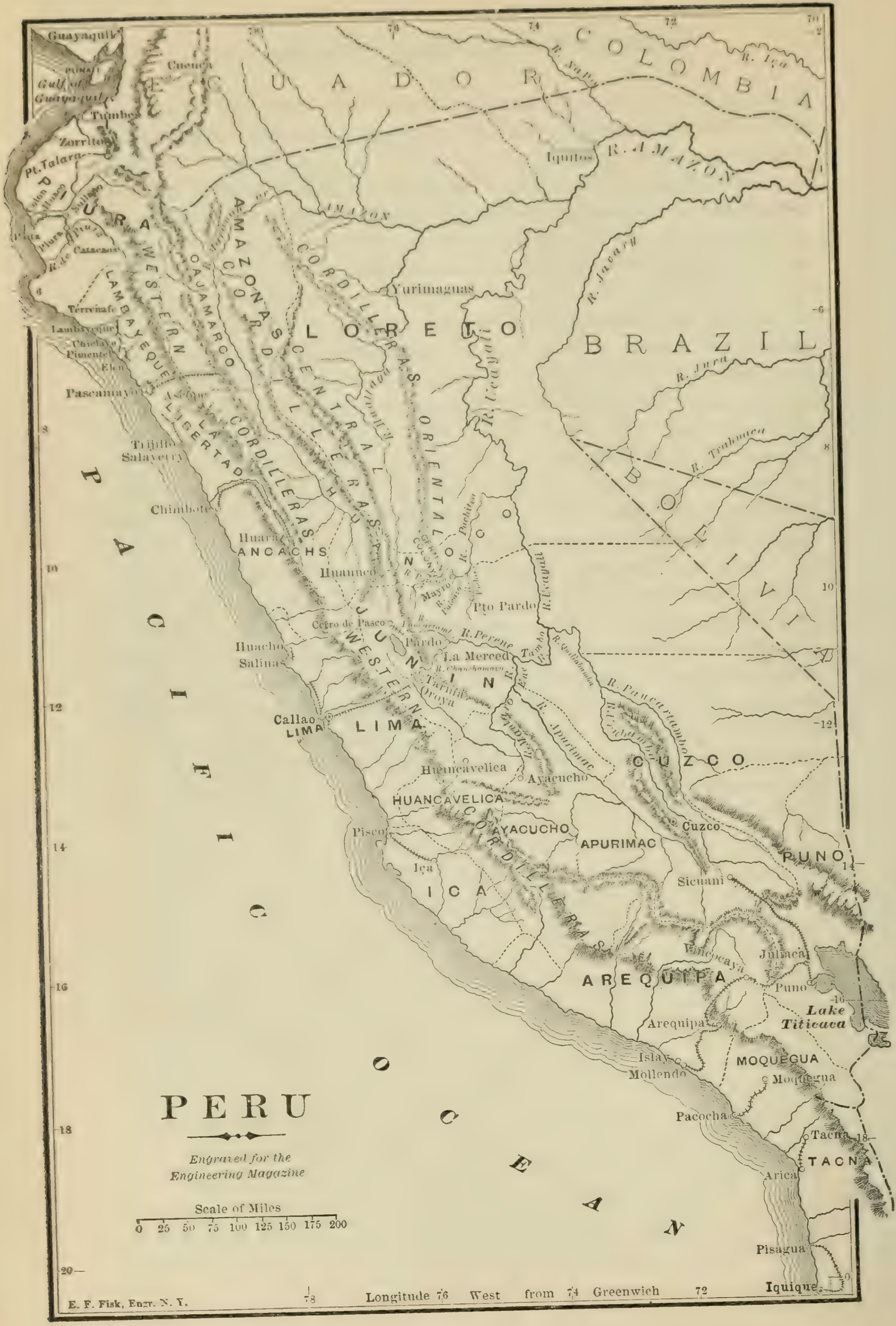
I take it that no criticism on modern American architecture can be complete without some mention, however short, of the great national effort in the Chicago exposition, but my remarks must be brief. From the point of view of architecture the show was a grand success, both as a demonstration of the ability of the architects of America to rise to the occasion, and also for the opportunity it gave of calling in the assistance of the allied arts of painting and sculpture. It fell to my lot in 1889 to visit the Paris exhibition to report thereon for the Architectural Association, and so I have had a good opportunity of forming comparisons. Of course the Chicago exposition was different in every respect to what one expected. One looked for some new development shown in either iron or terra-cotta, or both, or perhaps wood alone, being in the center of a country which is the center of the lumber market; but "extremes meet," and so we find an exposition of architecture on the wilds of the western prairie which is a collection of well-studied Parisian designs. There is something to be said in its favor, perhaps, as an object-lesson to Americans, and the whole scheme was certainly carried out with a thoroughness of purpose and a lavishness of money worthy of all praise. I must mention here a word of unstinted praise to Messrs. Adler and Sullivan for their Transportation building, a color scheme perhaps too novel and too new for the average American, but coming fresh as the first rose of summer to the jaded European.

Let us hope, however, that the imitative element will not cause the great classic designs of the Chicago fair to be reproduced for town halls, museums, etc., but that American architects, already advancing so rapidly along certain new lines of departure, will value the lessons they teach without copying the forms which they present to his eye ; if not, we shall see a great American classic revival which will go far beyond any craze we have had in England and do more to retard the true progress of art in America than if no exposition had been held.

In conclusion, I am certain that there is a great future for American architecture if only the architects will, as much as possible, express themselves in the language of their own times. No advance can be made by the wholesale copying of ancient buildings as has been done in one or two cases, constituting a retrogressive movement and showing a sad want of the appreciation of the true value of art.

The great styles must of course be studied and well studied, not for the forms with which they abound, but deeper still, for the principles which they inculcate, in the same way that one studies the literature of the past, not to be able to talk in a dead language, but the better to be able to do so in a living one. If this is done, and done with the earnest intention which a true artist has of producing works which shall reflect the hopes, needs, and aspirations of the life and character of the age in which he lives, a good result must be assured.

LONDON, March, 1894.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Engraved for the Engineering Magazine
Scale of Miles
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LIBERTAD
ANCACHS
JUNIN
LIMA
HUANCAVELICA
AYACUCHO
APURIMAC
CUZCO
PUNO
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AREQUIPA
MOQUEGUA
TACNA
WESTERN
CORDILLERAS
CENTRAL
ORIENTAL
R. AMAZON
R. Napo
R. Iça
R. Javary
R. Jurua
R. Ucayali
R. Perene
R. Apurimac
R. Paucartambo
Guayaquil
Gulf of Guayaquil
Cuenca
Tumbes
Zorritos
Pt. Talara
Piura
Terrenafe
Lambayeque
Chiclayo
Pimentel
Eten
Pascamayo
Trujillo
Salaverry
Chimbote
Huaraz
Huanuco
Cerro de Pasco
Pardo
La Merced
Tarma
Oroya
Huacho
Salinas
Callao
LIMA
Huancavelica
Ayacucho
Pisco
Iça
Cuzco
Sicuani
Vincocaya
Juliaca
Puno
Lake Titicaca
Arequipa
Islay
Mollendo
Moquegua
Pacocha
Tacna
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Iquique
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BUSINESS OPPORTUNITIES IN PERU.

By H. Guillaume, F. R. G. S.,

Consul-General for Peru at Southampton, England.

PERU awaits only the development of great natural resources to give her an important place in the world's commerce. Native enterprise is deeply concerned in the country's progress and a welcome is extended to all, of whatever nationality, who come prepared to extend the work of development. There are fine agricultural and pastoral lands, mines rich in the precious metals and copper and lead, petroleum-fields ranking with those of Pennsylvania and Russia, virgin forests in great variety, and immense sources of india-rubber. But, with an area one-seventh as great as that of Europe, the population does not exceed 3,000,000, more than half of which is composed of Indians, so that great need exists of an increase of population and additional capital to carry out on a commensurate scale the development of the natural riches.

The country is divided, by parallel ranges of the Andes, into four distinct regions: (1) the coast, extending along the Pacific for 1500 miles and inland for fifty miles or more, intercepted by sixty rivers flowing from the cordillera, and fitted for agriculture; (2) the Puna, a tableland 10,000 feet or more above the sea, lying between the western and central cordilleras, abounding in mineral wealth and wool-bearing animals; (3) the Sierra, also a tableland, noted for salubrity of climate, suited to the growth of all cereals and of wool, and containing the chief mining industries; and (4) the Montaña, or forest zone, extending eastward from the Andes, and watered by numerous streams which flow into the Amazon system, thus putting this region in touch with the Atlantic ocean. In this latter region india-rubber and many medicinal plants flourish, and the lands are particularly fitted for the growth of coffee, sugar, tobacco, and spices.

The advantages of railways were so early appreciated in Peru that by 1870 some $29,500,000 had been expended for their construction, but the ill-advised plan of constructing several isolated lines left the country without any commensurate system of communication. One of these lines (the Central) promises, however, eventually to fulfill what was expected of it—to give easy access to important mines and to con-

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NOTE.—The limits of Peru are in dispute at so many points that a map satisfactory to everybody concerned remains to be made. The map on the opposite page has been drawn after Steiler, without an opportunity to consult with Mr. Guillaume, who naturally upholds the claims of Peru to wider limits eastward than are indicated on this map.—THE EDITOR.

nect the capital (Lima) with some navigable affluent of the upper Amazon. The extension of this road to Oroya was officially declared fit for traffic on November 14, 1893. The famous Verrugas bridge, destroyed by floods in 1889, has been replaced by a cantilever steel bridge built by a New York firm. The engineers have pierced the

A STREET SCENE IN THE CITY OF LIMA.

HARBOR AND DOCKS AT CALLAO.

mountains with no fewer than sixty tunnels, and the locomotive finally makes its way through the Andes, eighteen miles from Callao, by the Galera tunnel, which is 3800 feet long, at an altitude of 15,660 feet, being the greatest elevation in the world at which a piston-rod is moved by steam. Within a radius of thirty miles from Oroya are several important towns and the famous Cerro de Pasco mine, while it is only sixty miles eastward to the navigable river Perene, which flows into the Ucayali and through that into the Amazon. The Peruvian Corporation, Limited, who now control the line, have the right to extend it to this or some other river outlet, and this offers great hope to the republic. Already the energetic people of the Tarma and Jauja valleys have begun to transport their cattle and coffee to markets on the coast by this line, giving a great stimulus to trade in those regions.

The Southern railroad has also become an important line, extending from the seaport of Mollendo to Arequipa (107 miles); thence to Puno, on Lake Titicaca (218 miles); and from Juliaca to Sicuani (116 miles). Eventually the railroad is to be completed to Cuzco, the former capital of Peru, beyond which are the rich gold-fields of Paucartambo and the india-rubber and other forests of the Madre de Dios. From the Puno terminus there is communication by steamers on Lake Titicaca with Bolivia, to be extended down the river Desaguadero, when the improvements by dredging now under way on that stream have been completed.

There are five other state railways which were ceded by Peru to

A VIEW OF THE CITY OF LIMA.

her creditors under the Grace contract, in 1889, having an aggregate length of 242 miles. There are also five privately-owned railway lines, which, though aggregating only 124 miles, serve an important purpose in the conveyance of the produce of the rich coast valleys to

THE CATHEDRAL AT CUZCO.

the nearest ports. In connection with these, many tramways have been laid for conveying sugar-cane and ores to the railways. Other favorable lines have been surveyed, and the government is likely to encourage their construction in a substantial way.

The Central railroad, so far as completed, has already proved the inestimable benefits of internal communication. The colony in the Chanchamayo valley, established by the government twenty-five years ago, now cultivates some 4000 farms, devoted chiefly to sugar-cane and coffee, the latter of which is expected to yield during 1894 some 60,000 quintals, of a quality which is in growing demand. The German colony of Pozuzo is also rising into prominence after many years of isolation for the want of roads. The Peruvian Corporation, Limited, have located on the river Perene some of the lands ceded to them under the Grace contract, and, for the benefit of the colony formed on them, the company have greatly improved the roads leading in this direction from Oroya and constructed fine wire suspension bridges over the rivers.* Thus what was formerly an arduous and hazardous mule journey of eight or ten hours has been reduced to two hours, and the charge for transportating merchandise has been reduced 80 per cent. Before entering into possession of these lands the Peruvian Corporation caused reports to be made upon them by Messrs. Ross and Arthur Sinclair, two well-known Ceylon planters, and Mr. P. D. G. Clark, curator of the royal botanical gardens at Peradeniya. The pioneer work was entrusted to Mr. Robert F. Mackenzie, C.E.,

A STREET SCENE IN IQUITOS.

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* That over the Colorado has a span of 160 feet and that over the Paucartamayo a span of 260 feet.

PORT MELLENDO.

who employed from 100 to 500 men for eleven months repairing existing roads and constructing thirty-five bridges. The roads are now the best to be found in South America. The territory occupied here by

THE MOLE AT PUNO.

the Peruvian Corporation comprises 1,250,000 acres, extending forty miles along the Perene, and for 12½ miles on each side of that stream. The climate here has proved to be healthful, and among the colonsts are to be found English, Norwegians, French, and Italians. The Indians here are peaceable, and, under proper supervision, make very good workers. There is every indication that in this and other similar regions there will shortly be a large demand for machinery for the preparation of coffee and cacao, sugar-mills, and general merchandise, including many articles of luxury, which the sale of coffee, the coming principal article of export, will enable the people to purchase.

In the opinion of many intelligent observers, the navigation of the rivers of eastern Peru, converging into the Ucayali and through it into the mighty Amazon, must be regarded, not merely as an alternate outlet for the produce of this region, but as the most direct and economical route to Europe, and, consequently, the railways over the Andes will in time exist mainly for the passenger traffic. The Ucayali is accessible from eastern Peru by two routes. Its tributary, the Pachitea, is navigable for its whole length, besides which the two principal affluents of the Pachitea may be ascended by steamer,—the Palcazu to Mayro (a little below the Pozuzo settlement) and the Pichis to Pardo. The Ucayali may also be reached by the Tambo, which is navigable at all seasons by steamers of 600 to 1000 tons as far up as the junction

THE STEAMER "YAVARI" ON LAKE TITICACA.

A BRIDGE ON THE PUNO RAILWAY.

of the Perene, already mentioned in connection with the Peruvian Corporation concession.

The outside world knows little of the steamer trading which exists already on the streams here named. Every year considerable quantities of freight from these waters is conveyed by steam-launches to Iquitos, the capital of Amazonian Peru, whence it is reshipped for Pará, at the mouth of the Amazon—a distance of 2251 miles—to be despatched to American and European markets after having completely lost its identity of origin. Custom-house returns at Iquitos show the yearly shipment from that port of nearly $750,000 worth of india-rubber, mainly from the Ucayali, Pichis, Pachitea, Tambo, and Perene, for which payment is made chiefly in cottons, cutlery, hatchets, and provisions. At the junction of the Perene and Tambo, for instance, a firm of rubber-gatherers are located, employing 2000 Indians and running some small steamers, which they own, to Iquitos—a distance of about 900 miles. There are many other similar stations, devoted to the india-rubber and other industries, including some on the upper waters of the Huallaga, another important tributary of the Amazon. There is a monthly steamer-service as far down as Yurrimaguas, on the Huallaga, whence other steamers connect with the Amazon. Some of these stations have been stocked with cattle, carried on men's backs over the mountains when young. Almost everywhere there

THE NEW BRIDGE AT AREQUIPA.

is an opening for the introduction of small river-steamers of the type which American builders have constructed for the rivers of Colombia, and which are better suited for their purpose than many of those now used in Peru. On these rivers the petty trading must soon give way to more dignified commercial transactions, and barter will be supplanted by the export of valuable agricultural products which

CROSSING THE PAUCARTAMBO ON THE TELEFORD, 1893.
[A new suspension bridge of 260 feet span now stands here.]

A COLONIST AND FAMILY ON THE RIO PERENE.

should even now be finding their way to European markets. The Peruvian government, recognizing the future importance of this feature of development, has placed itself upon record in encouragement of the extension of river navigation.

The sugar production of Peru, already important, promises to be largely augmented when modern machinery and economical workings are more generally adopted. Owing to the introduction of improved machinery on some of the larger estates, the output of 1891 was 20,000,000 pounds greater than in the preceding year. No other country in the world combines such favorable conditions as does the coast of Peru for the growth of the sugar-cane. Not only is the soil of surpassing fertility, but the absence of rain in this region permits the cultivator, by means of irrigation canals, to supply the exact amount of moisture needed by the plant, and at the time when most beneficial to it. The climate is dry and warm, and so equable that one crop of cane follows closely upon another, so that the sugar-mills can be kept constantly running, instead of remaining idle for months as in the West Indies. Many Peruvians have made large fortunes in sugar, and their estates are models of what a sugar-estate should be. The Tuman estate, belonging to the sons of the late president, Don Manuel Pardo, in the Chiclayo valley, is a very encouraging example of the success attending the introduction of modern appliances. Many other properties are fitted with the latest machinery, principally supplied by English firms, though others have been fitted by Americans, French, and Germans. They often have extensive tramways which bring the cane to the sugar-house from the fields, and the electric light is used. A considerable portion of the sugar product is converted into rum for home consumption and for export to the neighboring republics. The value of the sugar-estates in the Santa Catalina and Chicama valleys is estimated at over $25,000,000, although until 1866, when irrigation was commenced there by Don Louis Albrecht, who discovered the existence of an old Inca aqueduct and repaired it at a cost of $8000, the Chicama valley was practically a desert. It is expected that during the next few years many sugar-estates will pass into the hands of English companies, as has been the case with the Cartarvio estate of the Messrs. Grace.

Cotton is grown profitably at many points along the coast, but principally in the northern department of Piura. The indigenous species known as "rough Peruvian," grown in the time of the Incas and still found enveloping bodies taken from the ancient tombs, is unrivaled by any other cotton known. It is obtained from a large tree which continues to yield from thirty to fifty years, and in favorable seasons two crops per year may be gained. The average yield on the plantations is 300 pounds per acre, after deducting the weight of the seed. The cotton exported goes to England, where it commands a high price for the reason that, when woven with wool, it is exceedingly difficult to detect the cotton fibers. Indeed, it is claimed to greatly

THE NEW ROAD TO THE PERENE, FROM LA MERCED.

A SCENE IN THE POZUZO VALLEY.

increase the strength and durability of woolens, to prevent shrinkage, and, in the case of dyed goods, to take fast colors. Not only are cotton-mills being erected in Peru with a view to stopping the importation, at least of the coarser cotton goods, but cottonseed-oil mills are

VIEW OF LA MERCED AND THE RIO CHANCAMAYO.

A SUGAR-ESTATE IN THE CHANCHAMAYO VALLEY.

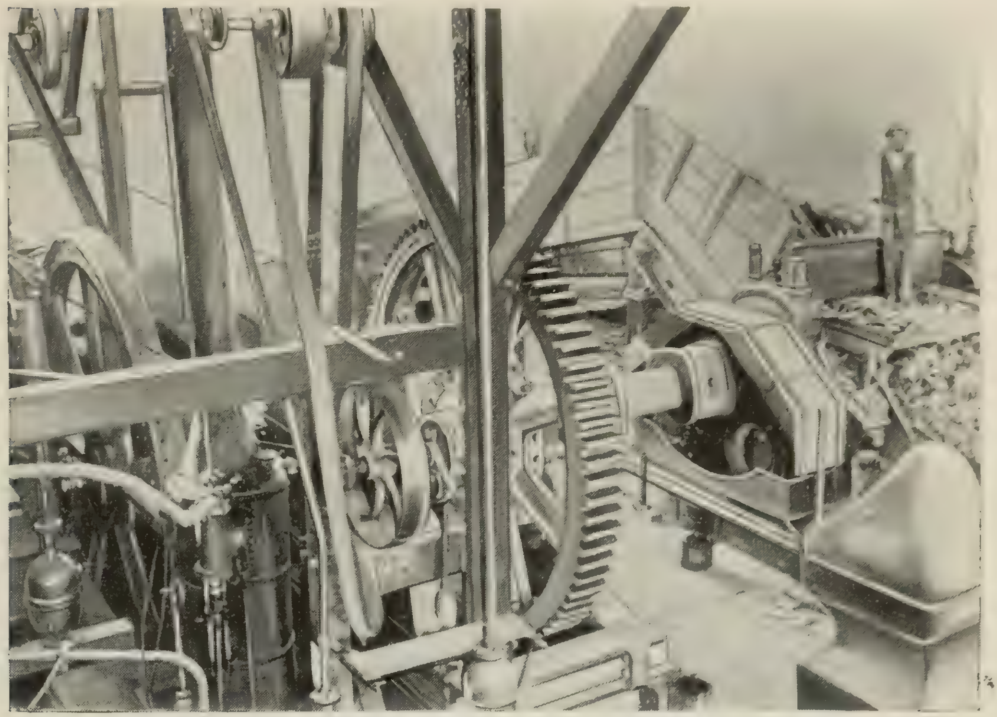
in operation, the product being used in large quantities in the manufacture of soap.

The coffee production has not long equalled the domestic demand, but of late it has increased until some has been exported. Its quality has attracted such favorable attention that foreigners are beginning to settle in Peru to become coffee-planters. All the cereals, tobacco of excellent quality, the ramie-plant, and many other crops may be cultivated with profit. In addition, the wool-growing industry has made a beginning that cannot fail to lead to an important source of wealth, and, in the near future, to the establishment of manufactories for the coarser products of wool.

From recent explorations it is believed that Peru contains the second largest petroleum area in the world, much of it situated in close proximity to the coast, and the fact that the oil is found nearer the surface than in other countries offers a favorable condition. The discovery of petroleum will permanently benefit the industries of Peru, as oil has already supplanted coal as fuel on the railways and steamers and in some of the smelting-works, an economy which may be gaged by the fact that the steam-coal previously used had to be imported from England. An important petroleum deposit exists in the department of Piura, where a zone examined by a United States engineer, Mr. E. P. Larkin, comprises an area of 4,400,000 acres, which is larger than that of Pennsylvania, which produces 84,000,000 barrels

THE TUMAN SUGAR-ESTATE.

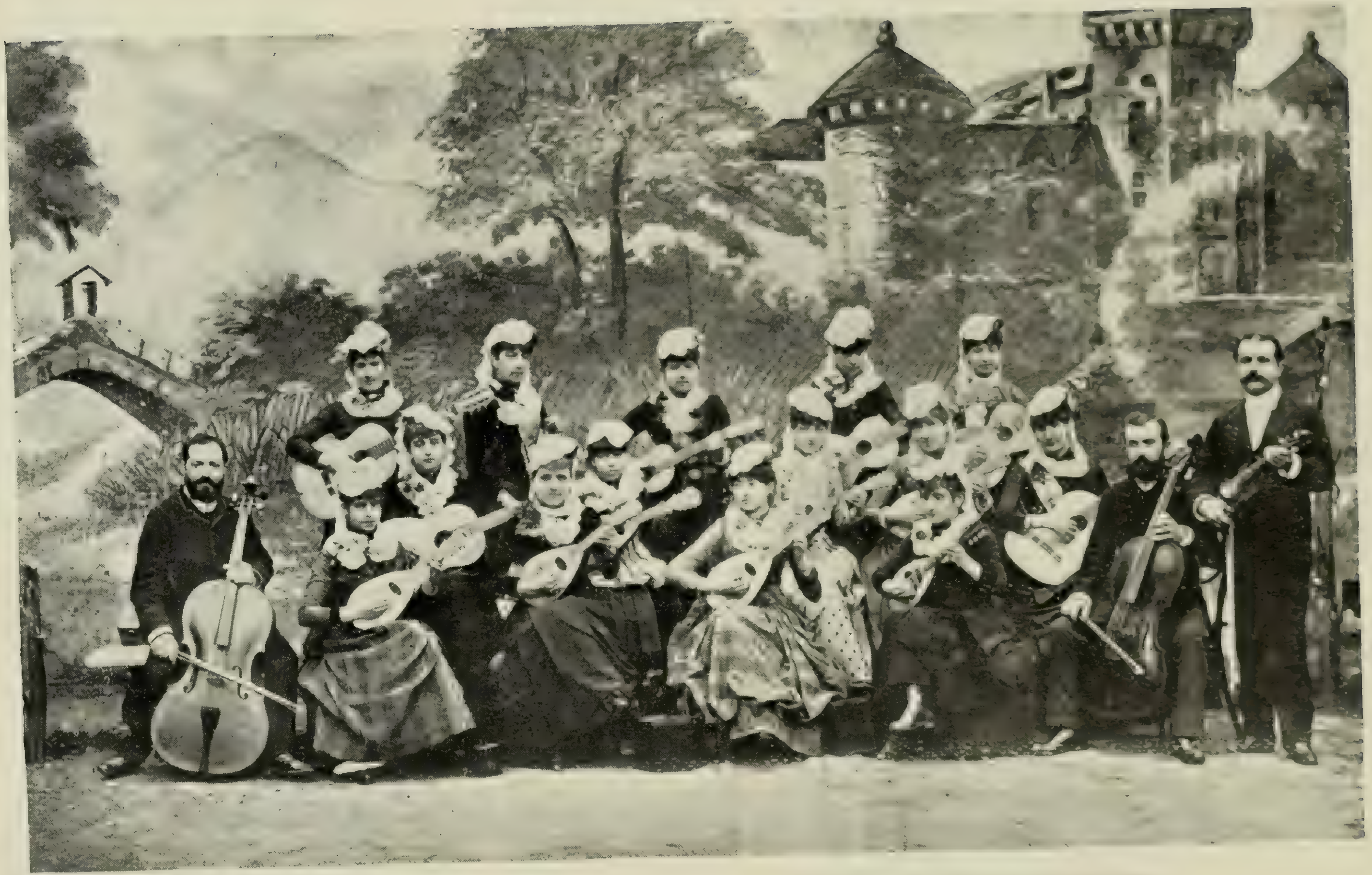
of oil annually. Petroleum is found in other departments, and is believed to extend more or less throughout Peru. The wells which have been bored do not as yet exceed 800 feet in depth, and oil frequently is struck at thirty feet below the surface. By making the wells deeper the oil seems more likely to rise without the aid of pumps, forming fountains, some of which have flowed regularly for months or even years. In the department of Piura forty-four wells are producing. At Zorritos one well has yielded oil for seventeen years, and there are wells in this region which yield from ten gallons to eighty barrels per hour. Peruvian refined kerosene has received several gold medals at several great exhibitions. Refineries are being erected at various points, but the progress at Talara has been most rapid, the buildings and machinery being of the first order, forming, together with a lighthouse, wharf, electric-light plant, and telegraph- and telephone-services, the best establishment in South America. It is in the hands of an English company with a capital of $1,250,000, and there are now fifty wells producing oil on this property. The company own a special tank steamer for the shipment of the oil. Some shipments have been made to Shanghai, and it is hoped that the beginning thus made will lead to an important trade with China and Japan. Many other companies have been organized, or are in process of organization, and, there now being no doubt of the abundance of petroleum in Peru, the



MACHINERY AT THE TUMAN SUGAR-ESTATE.

hope is entertained of an important advantage from the fact that Peru is nearer to Japan, China, New Zealand, and Australia than is any part of the United States.

HAULING SUGAR-CANE ON A TRAMWAY.



LADIES AND GENTLEMEN OF LIMA GIVING A CONCERT FOR A CHARITABLE PURPOSE.

Of the mineral resources of Peru, themselves constituting a vast source of wealth, the prospective development of which has served to stimulate the development of the railways, and which might reasonably be expected to be of interest to mining engineers and to the manufacturers of mining equipment in the United States and elsewhere, there is much to be said, but as the space allotted to this paper is necessarily limited, and as the writer understands that the Magazine has in hand from other contributors something bearing upon this subject, it will not be farther touched upon in this connection. Another subject of importance to the engineering world is the vast system of irrigation, by means of which agriculture was a profitable pursuit among the ancients, and the revival of which, now in progress on a large scale, promises much for the future of the country. The latter subject alone is worth treatment to the extent of a separate article in the Magazine.

It may be of interest here, as indicating the extent to which Peruvian commerce has already grown, to give the latest available returns of exports from the seaports, which cover the year 1891 :

Agriculture—		
Sugar	$3,169,449	
Cotton	1,214,140	
Medicinal leaves	345,830	
Rice	150,220	
All other	341,482	
		$5,221,121
Animal Industry—		
Live and dead animals	$188,747	
Hides	294,388	
Wool—Sheep	304,650	
Alpaca	557,181	
Vicuña	15,746	
		1,360,712
Mining—		
Silver	$3,681,355	
Gold	103,623	
Copper	3,817	
Marine salt	404,813	
		4,193,608
Manufactures—		
Flour	$230,534	
Straw hats	183,861	
Wines	103,541	
Boots	33,148	
Lubricating oil	33,092	
All other	90,210	
		673,586
Miscellaneous		170,690
Reëxports		751,409
Total exports		$12,371,126

The exports and imports, divided among the various countries sharing the trade of Peru * during the same year, were as follows:

COUNTRIES.	Exports.	Imports.
England	$5,811,973	$6,289,380
Germany	1,111,457	2,865,760
Chile	1,190,479	1,103,274
France	354,234	1,576,587
United States	278,015	1,323,875
All other	3,624,967	2,007,551
Total	$12,371,126	$15,166,427

In conclusion, the question arises: Who shall have the Peruvian trade? England,—rich in colonial possessions and with markets all over the universe open to her,—Germany, and France are still extending their colonial empire, and dividing among themselves the map of Africa. The United States, on the other hand, with no colonial policy to pursue, have become nearly foremost in the manufacturing world, and need to establish new commercial relations that their manufactured articles may have a ready market. Here such a market lies at their very feet; whether they will obtain here the outlet which they desire time alone will prove, but of the country's vast resources I can quote nothing more appropriate than the words of the late Professor James Orton, himself a North American, who was an enthusiastic and extensive traveler in Peru:

"Peru has immense capabilities. She is the France of the South American continent . . . These rich resources, lying almost at our very doors, must soon appeal to that restless spirit of enterprise and commercial activity which, not content with its vast triumphs, longs for new conquests and a wider field of exercise. One looks forward to the dazzling future of this great valley, when the ships of all nations will crowd the network of rivers for the gold and perfumes, the gems and woods of the great western Ophir."

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* No account is taken here of the commerce of Iquitos, of which mention has been made elsewhere in this article. H. G.

BREAKWATERS, SEA-WALLS, AND JETTIES.

DESIGNS AND COMMERCIAL IMPORTANCE.

By George Y. Wisner, M. Am. Soc. C. E.

THE history of the material and commercial progress of any country is identical, to a great degree, with that of the development of inland transportation and the establishment of terminal ports of easy access for foreign commerce. The home value of the products of manufacturing and agricultural enterprises is the price they will bring in the markets of the world, less the cost of transportation ; consequently any decrease in transportation rates adds a like amount to the value of all productions, whether for export or for home consumption, and gives the producer a corresponding advantage over those of competing countries.

The secret of cheap transportation lies in the ability to handle and carry large quantities of freight for long distances without change. This being the case, the commercial interests of a country require that the development of the means for interior transportation and for safe and commodious harbor facilities for foreign commerce shall form links of the same general system of improvements. The demand in commercial countries for deep-water outlets is such that millions of both public and private funds are expended annually to develop whatever natural facilities may exist, and the maintenance of such channels, when obtained, depends largely upon properly-designed systems of breakwaters and jetties.

England, with scarcely any portion of the country more than a hundred miles from a good harbor, has maintained her maritime supremacy with little to fear from any of her commercial neighbors except the United States, where the admirable system of inland waterways renders the cost of interior transportation almost as cheap as that of ocean traffic. The magnificent coastline of England is studded with harbors which, where the natural depths were insufficient for the commerce of the ports, have been improved and protected by sea-walls and breakwaters from wave-disturbance and from deterioration from deposits of sand-drift. In France, the principal maritime harbors are artificial and the structures are monuments to the engineering genius of that nation. Germany, with a great natural system of inland waterways, has but few maritime ports of importance, and would no doubt be glad to increase her facilities for foreign commerce by taking the harbor-lined coast of Holland under her protecting care.

Russia has watched the coasts of Turkey with covetous eyes for years and, failing to obtain these valuable outlets for her commerce, is now building a railroad across Siberia to her deep harbors on the Pacific, which eventually will bring her in such close connection with China that careful observers are inclined to think it will result in a large slice of the Celestial empire becoming subject to Russian rule.

The improvement of harbors in the United States extends only over a period of about ninety years, during which time upwards of $250,000,000 have been expended by the general government for such purposes. About $40,000,000 of this has been used for improving the harbors and waterways of the great lakes, where the system of jetties and breakwaters for improving harbors is perhaps more general than on any other coast in the world. The average extent that the lake harbors and connecting waterways have been deepened is approximately eight feet, at an average cost of $5,000,000 for each foot gained in depth. This may seem somewhat expensive, but, when the cost is considered in connection with the benefits derived, it is a mere bagatelle.

Prior to 1871, the ruling depth of lake ports and connecting channels in the United States was about 11 feet, which was then increased to 13 feet. In 1873 the depth was increased to 16 feet. The freight-rate on grain from Chicago to Buffalo, before the channels were deepened, averaged about 8 cents per bushel, but the rate has since decreased to less than 2 cents. The grain delivered at Buffalo in 1892 amounted to 182,000,000 bushels, on which the cost of transportation was $11,000,000 less than it would have been with the freight-rates prevailing before the channels were deepened. Since the grain freight amounts only to about one-fourth of that affected by the cheaper rates, it is evident that the amount saved to producers in a single year is nearly as much as the entire improvements of lake channels and harbors have cost. The rapid growth of American commerce, the vast coastline to be improved, and the limited funds to be had for such purpose, created a demand for immediate results at small expense, which in many instances has necessitated the construction of works of a temporary character. The replacing of such works with permanent structures, which will at the same time increase the harbor facilities, are problems well worthy of careful consideration.

The general system of breakwater construction on the lake-coasts has been that of timber cribs filled with stone. In the lake climate the average life of timber above water is about eleven years, and, with the low cost of lumber during the early years of harbor improvement, renewals of superstructures could be made for an amount less than the interest on the investment needed for permanent structures. The increase in the cost of lumber has so changed this ratio that it will be more economical in the future to make use of more lasting material for construction purposes. These structures below water-level are generally in good condition for making foundations for permanent concrete superstructures, the sections of which should be so designed that wave-shock will be a minimum. The only serious failure of such works which has occurred recently was that at Buffalo harbor, last year, where a new structure costing upwards of $100,000 was washed away in a single storm. In this case, however, the government engineers refuse to give any information as to the character of the construction or the cause of the failure, which would indicate that it was due to faulty engineering.

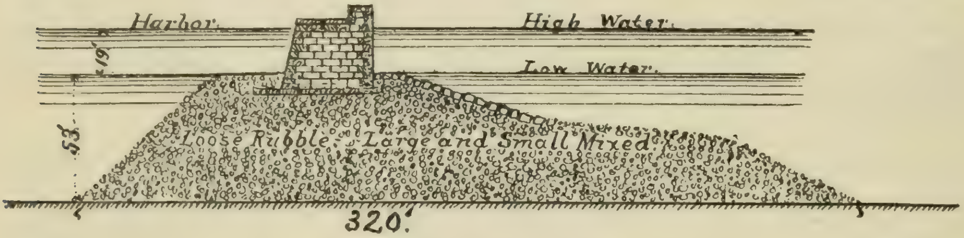
On our sea-coasts various devices have been tried to avoid the expense of rock and masonry construction, but, with the exception of the brush jetties at the mouths of the Mississippi and Brazos rivers, where the sediment from those streams protect the works from the ravages of the teredo navalis, little now remains of the original structures. Where such works are being rebuilt, riprap is generally used, built into mounds and allowed to assume a natural slope under wave-action, similar to the breakwaters at foreign ports, of which a few typical examples are named in the following table :

NAME.	Kind of Work.	Depth of Water.	Sea Slope.	Width of Base.	Cost per Lineal Ft.
		Feet.		*Feet.*	
Portland	Rubble mound with masonry above low water.	50 to 65	5 to 1	270	$ 600
Holyhead	Rubble mound with masonry above low water.	20 to 50	12 to 1	460	950
Plymouth	Rubble mound.	40 to 50	5 to 1	360	1,000
Dover.	Solid masonry.	40 to 60		82	1,800
Algiers	Rubble mound with slopes of large Beton blocks.	30 to 90	1 to 1	250	600
Cherbourg	Rubble mound with masonry above low water.	50 to 70	7 to 1	320	1,080
Marseilles.	Rubble mound with slopes of large blocks. Concrete parapet.	30 to 60	1 to 1	260	540
Colombo	Concrete blocks on rubble mound.	20 to 40		130	600
Delaware Breakwater. . .	Rubble mound.	30	1½ to 1	160	530
Sand Beach, Lake Huron	Timber cribs filled with stone.	30		38	175

The sea-slopes given in the table, which the loose rock has taken under wave-action, are those at or near low water. In depths of over twenty feet below low water the slope is usually greater than two horizontal to one vertical.

At Portland, Holyhead, Plymouth, Cherbourg, and Delaware breakwater the products of the quarries were used directly as broken up by blasting, without regard to placing the different size of rock where its resistance to movement would be sufficient to withstand the sea forces without assuming such low slopes as to make the width of structures unnecessarily great. Since the force of waves tending to move any obstruction increases as the area of the exposed surface—or as the square of one side of the block—and the resistance to moving as the cube of such dimension, it is evident that, if the larger blocks of rock be placed so as to receive the heaviest shocks from the waves, a much steeper slope may be maintained, and consequently a much narrower structure be made to accomplish the purpose required.

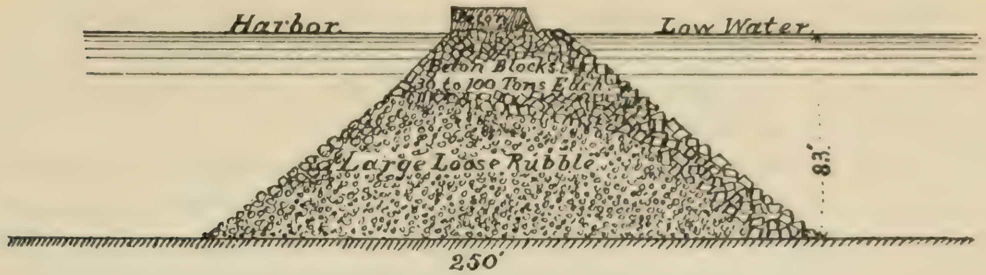
Placing material in the works with the respective sizes so arranged as to resist wave-action in the best manner increases the amount of void in the structure, and correspondingly decreases the amount of rock required. With fine and coarse material dumped into a jetty as broken up in the quarry, the voids in the mound may not exceed 10 per cent. of the volume, whereas, if placed with regard to size, the voids will exceed 30 per cent., and such arrangement will consequently reduce the amount of material required by more than 20 per cent.



SECTION OF CHERBOURG BREAKWATER.

English engineers seem to have adhered to the same general system in nearly all their works of this kind, but the French, after the construction of the Cherbourg breakwater, saw the error of their ways, and used the smaller rock for a core of the mound and the large blocks for protecting the slopes where exposed to the impact of waves. The economy of this method of construction is very clearly shown by the work at Algiers, where the depth of water was 50 per cent. greater than at Cherbourg, while the width of structure required was only two-thirds as great, and the cost per lineal foot only a little more than one-half.

The forces to which breakwaters are subjected from impact of waves

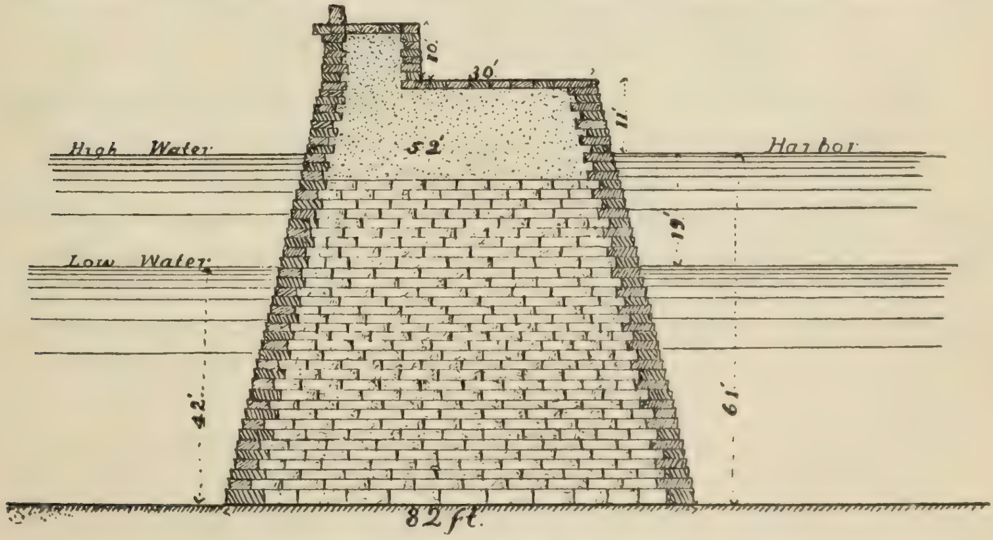


SECTION OF ALGIERS BREAKWATER.

are sometimes enormous, and in many cases are actually increased by the form given to the structures. In deep water the motion of a particle is a closed curve, in which the forward motion in the crest of wave is somewhat in excess of the backward movement in the depression, producing a general surface resultant in direction of the wind. When any obstruction is encountered the wave-motion is converted into one of translation, such that the striking force is sometimes several tons per square foot.

Below the plane of wave-disturbance the effect is simply one of pressure, but from thence to the surface the power to destroy increases very rapidly. At Colombo, Ceylon, waves 15 feet high in 40 feet depth of water have been observed, in breaking against the breakwater, to throw spray 120 feet to 150 feet high, indicating a pressure from wave impact of from four to five tons per square foot. At Cherbourg the height to which spray is thrown shows a striking force nearly as great as at Colombo, and on several occasion has resulted in serious damage to the superstructure.

At the harbor of Wick, on the northern coast of Scotland, the breakwater is founded in a depth of 50 feet of water, and consists of

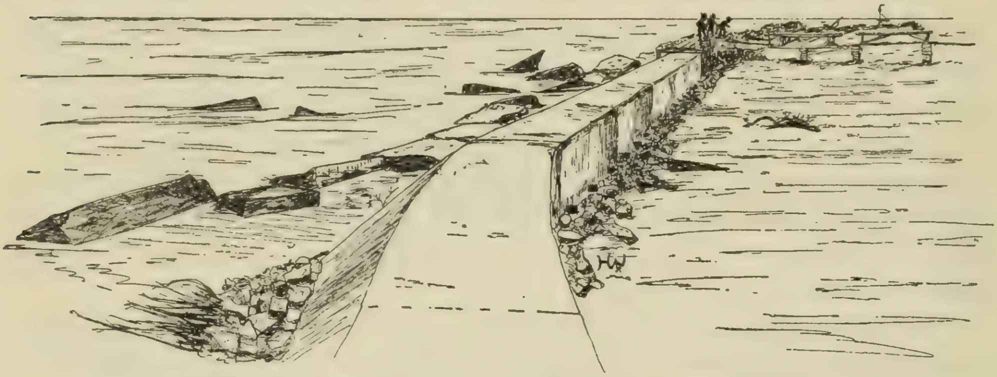


SECTION OF DOVER BREAKWATER.

a concrete superstructure built on a rubble mound 18 feet below low-water level. During a storm in 1873 a considerable portion of the concrete wall was wrecked, and a single piece of over 1500 cubic yards was moved bodily out of place.

Where the riprap foundations, on which such structures are usually founded, have a low slope, a motion of translation is given to the wave before reaching the wall which greatly increases the striking force. To reduce the impact of the waves to a minimum the slope below surface of sea should be made as steep as possible and the outer face of the superstructure so far inclined from a vertical that the wave-pressure will be downward instead of horizontal.

The principle asserted by English engineers in favor of vertical walls for breakwaters is that oceanic waves in deep water are purely oscillatory and exert no impact against vertical barriers which, consequently, have only to withstand the hydrostatic pressure due to the height of the impinging waves. The wreck of many important works, however, has shown the fallacy of this conclusion.



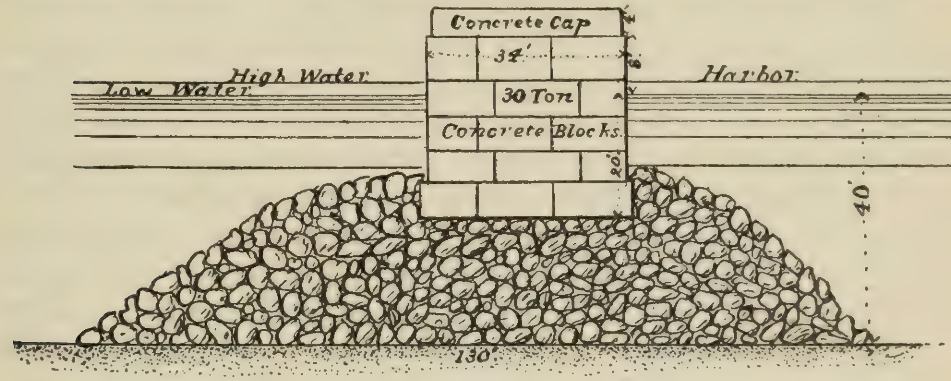
NEW CONCRETE WALL AND JETTY AT SOUTH PASS.
[Wreck of the old Eads wall and jetty at the left.]

The accompanying cut of the new concrete sea-wall and the wreck of the old wall, at South Pass, very clearly illustrates the results ot the two plans of construction. The original wall, built by Captain James B. Eads in 1879, had a vertical face towards the sea of about five feet, and was partially wrecked within a year after being constructed. The new wall, built by the writer in 1889, contains less material per lineal foot than the original structure, and has withstood some of the most severe storms ever experienced on that coast without being damaged in the slighest degree.

The breakwater at Colombo harbor is of typical English design, and, while it has withstood the tremendous shock of the waves for ten years, such result is more due the substantial method of construction than to being designed so as to reduce wave impact to a minimum.

The exposed portion of the breakwater is in 40 feet of water, and is constructed of 30-ton concrete blocks, surmounted by a concrete cap 4 feet thick, and is founded on a rubble mound 20 feet below sea-level. The concrete blocks are set at an angle of 20° from the vertical, in direction of the axis of the breakwater, and have grooves at the joints, which, when the wall was completed, were filled with concrete, making the structure practically monolithic. If from low-water surface the breakwater had been given a slope for half the width of wall, a large amount of costly material might have been saved and the shock from wave impact greatly diminished.

The functions of jetties and breakwaters are usually threefold: (1) to concentrate river and tidal currents through the proper entrance channels; (2) to prevent sand and littoral drift from entering and being deposited in the harbor; and (3) to form shelter from heavy seas for the safe entrance and anchorage of ships. In a majority of cases the deterioration of harbors is largely due to the movement of sand parallel with the adjacent shores, from wave and current action, and, if the structures are not so designed as to prevent such drift from being deposited under the shelter of the works constructed, they are certain to result in total failure. Littoral currents alone are not generally of sufficient force to produce erosion, but, when aided by wave-action, the drift is picked up and transported along the coast until some shelter is found where wave-disturbance is not strong enough to hold the particles in suspension. Unfortunately, this condition often occurs behind breakwaters designed for the protection of harbor-entrances and anchorages.



SECTION OF COLOMBO BREAKWATER.

A fair example of such faulty design is shown by the rapid shoaling which has taken place in the great harbor of refuge formed by the Delaware breakwater, completed in 1869 at a cost of $2,750,000. The anchorage sheltered by the breakwater was from 25 to 30 feet deep when the work was completed, but has gradually shoaled so that at present there is but little of the protected area over 16 feet deep, or, in other words, the harbor is practically worthless for the purpose for which it was constructed.

At the recent International Engineering Congress Mr. J. P. Griffith, of Dublin, said:

> The keynote to the success which has attended the efforts made to improve the Dublin bar has been due to a full appreciation of the littoral and tidal currents by the engineers who designed the works. Dublin bar has been improved by artificial scour resulting from the construction of a tidal reservoir of 2500 acres, enclosed by two great piers extending out over the strands of Dublin bay. These piers have been so formed as to make the outward scouring current flow in unison with, *and not in opposition to*, the littoral currents of the bay.

The failure to fully appreciate the effect of littoral currents by engineers has been the cause of their adopting plans for improving several important American harbors which have totally failed to produce the results anticipated and predicted. The design for the improvement of Galveston harbor by means of jetties is a notable example of this class of work. The general direction of the littoral drift on that coast is from the northeast to the southwest; yet the jetties, on which upwards of $4,000,000 have already been expended, are faced directly to the eastward. The results thus far obtained have been an increase of channel depth on bar of about two feet, an abnormal movement seaward of the outer face of the bar, and the development of an eddy to the south of the works of such magnitude that the city front has been washed away in places a width of nearly 1000 feet, while, during the past ten years, the loss of nearly sixty acres of city property has occurred. The problem that now confronts the citizens of the Island City is, whether they will have any city left by the time a deep-water channel is obtained across the harbor bar.

GOLD-DREDGING IN NEW ZEALAND.

By T. A. Rickard, F.G.S.

THE south island of New Zealand is the Switzerland of the antipodes. The warm, wet winds of the Pacific, arrested by the lofty mountain-ranges that guard the western coast, are compelled to precipitate their moisture for the maintenance of the snowfields, glaciers, and fresh-water lakes whose varied beauty excites the wonder of the traveler and the admiration of the artist.

The melting snows feed streams the volumes of whose waters enables them to rank among the great rivers of the earth. The most important is the Clutha,* with its tributaries the Shotover and the Kawarau. This noble river flows through the province of Otago, and to the dwellers in that gold-mining region it is what the Nile is to the Egyptian fellaheen. The Clutha does not, it is true, flow through lowlands of great fertility, but it washes the rocks of gold-bearing highlands, and the mud which enriches the flat plains of the delta is comparable to the tribute of golden gravel brought down from the hills by the more rapid waters of the southern river. The anxious cultivator in the land of the Pharaohs does not watch the rise and fall of the historic river of the north with greater anxiety than does the miner the swollen torrent of the stream whose quick rise or gradual fall may mean either the cessation of work and the flooding of his working ground, on the one hand, or the ingathering of a golden harvest, on the other.

The names of the Clutha and its tributary streams are interwoven with much of the early history of gold-mining in New Zealand. It was at Gabriel's Gully, near Tuapeka, in June, 1861, that the discovery was made that started the flood of immigration and woke into activity the land which Captain Cook had discovered nearly a century before. Since 1861 New Zealand has yielded about 12,000,000 ounces of gold.† Of this a large share has come from the gravel lying along the banks of the rivers of the south island. The mountain streams flow through dark ravines threading an alpine land whose lofty ranges are forever crowned with snow. Lakes are common and their waters are marvelously clear and deep. The bare ridges which they reflect have a coronet of snow which is their only claim to nobility of aspect. Approaching the sea, the rocky gorges give place to narrow valleys of pastoral land and rolling foothills whereon multitudinous flocks of sheep fight for existence with the rabbit, the pest of the colonies.

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* Also called the Motyneux.

† The production for the year 1892-1893 was 228,659 ounces.

The rock of the upper country, the miner's domain, is for the most part a schist, a fissile soft rock, diversified by innumerable seams of quartz which give it a characteristic foliated or "leafy" appearance. It is to the rapid weathering of this rock that is due the configuration of the country and the enormous quantity of gravel transported, and afterwards accumulated, by the rivers.

The chief agent in this work of degradation is the frost, which to the gold-miner is what the earth-worm is to the farmer. One disintegrates the rock, the other turns over the soil. A little drop of the rain of heaven penetrating a crack or cranny becomes slowly contracted by lowering of the temperature until 4° C. is reached, when it expands suddenly so as to serve as a resistless lever to which the rock, however adamantine, must perforce yield. At high altitudes the difference between the temperature of the day and the night is very marked. To it are due the severest hardships of mountaineering. The action of frost is therefore increased, and, in a fissile rock like the schist of Otago, there is afforded a material peculiarly subject by its structure to easy degradation.

The schists contain gold, sometimes confined to distinct seams or veins of quartz, but more commonly and more widely disseminated through certain portions of the rock formation within belts or areas whose boundaries are indefinite and indeterminable. Such deposits of gold are rarely valuable to man because the quantity per ton of rock is too small for profitable exploitation; but nature, in her slow and patient way, has done what man often tries to do in a clumsy and hurried manner,—that is, concentrated the values so that they have become economically important. The wind and rain sweep the fragments of the rock already shattered by the frost into the stream, which hastens to deliver them to the river. The waters of the river separate the heavy particles from the light and in so doing assort the valuable from the valueless. Wherever the swiftness of the current is retarded the heaviest particles are deposited while the lighter sands are borne along to the distant sea. Thus the gold becomes laid down behind projecting bars or under the shelter of rocky bends.

The river Clutha affords many instructive lessons in physical geography. It is comparable to a "ground sluice." The miner, when he is working a deposit of gold-bearing gravel, takes his pick and shovel and cuts out a channel (two to three feet wide and one to two feet deep) in the underlying solid rock (the "bed rock"). This is called a "ground sluice." He then proceeds to conduct a stream of water under pressure by means of a pipe against the face of the gravel, washing it down into the sluice. The ridges, hollows, and other irregularities of the rocky bottom serve to arrest and collect the gold, while the water carries away the lighter, valueless material. Sometimes this arrangement is impracticable; so he makes a wooden launder or box whereby to conduct the gravel and water; across the bottom of this he places strips of wood or uses other devices to impede and interrupt the current and permit of the settling of the gold. Such a launder is a "sluice-box" and the traps for the gold are called "riffles" (America) or "ripples" (Australia).

The Clutha, with its seven-knot current, sweeps down through the easily-eroded rocks into which it has cut for itself a natural sluice-way, the riffles of which are the rocky bars, while its head is at the feet of the glaciers and its lower end empties into the Pacific. Its course is characterized by a succession of narrow gorges followed by wide flats. Where the river now flows there was once a chain of fresh-water lakes cut out by the glaciers which have since receded further inland. These lakes in a bygone geologic period received the tribute of the upper highlands in the form of the gold-bearing gravel which was laid down in their quiet depths. In later times the Clutha worked its way from lake to lake, and, having finally worn down its channel deep into the rock, it emptied the lakes, cut through the deposits which they had accumulated, and now flows unfettered to the sea.

The first gold-seekers who, in 1861, explored the sands of the Shotover and the Clutha, restricted their search to the easily-accessible deposits of gravel which the work of centuries had accumulated in sheltered places. When the gold-bearing sands were found to extend under the main waters of the river they turned the stream by means of artificial dams. This is ordinary placer-mining. The rich alluvium, however, was found to exist in places where it was too costly or even impossible to divert the stream; in such places the digger was compelled to wade knee-deep, and, standing shovel in hand, to snatch with difficulty the golden sand which appeared to increase in richness the less accessible it became. To raise sand from the bed of a stream with a shovel is difficult enough at all times. It is impossible where the current is rapid. The next step, therefore, was to contrive a ladle or spoon with which to scoop up the river-bed. A piece of hide attached to an iron rim was arranged behind the modified blade of a shovel and fastened to the end of a long pole. The territory available for work was thus considerably enlarged; but the exhaustion of the gravel near the banks caused the distance from the shore to be steadily increased. Soon the water became too deep for this kind of work, so a barge or punt was built, the pole was lengthened, the scoop was enlarged, and mere hand-power was replaced by a winch and tackle. This now became what is known as the "spoon-dredge." It served its purpose and had in turn to step aside for something better. The numerous hydraulic mines began about this time to send down their débris or tailings, which slowly covered the river-bed with an increasing depth of valueless gravel. The extra work, essentially unprofitable in its character, which this threw upon the spoon-dredge, soon rendered it necessary to invent some better machine. The first step was to replace human muscle by the greater power which went past unexpended in the current of the river itself. The winch was succeeded by the water-wheel. Thus the "current-wheel dredge" was invented. One scoop was replaced by several worked by an undershot water-wheel erected by the side of a barge. The idea was a good one, but its successful application was hampered by the fact that, being adapted only to work in the full force of the current, it could not be utilized in the back-waters, pools, and other places where lay the richest parts of the river-channel. Steam then replaced water-power, the "scoops" or buckets were largely increased in number, and they were so arranged as to work in an endless series. Thus was evolved the "bucket-and-ladder dredge." Further improvement was made by the addition of revolving screens for sizing the gravel, by introducing winches for mooring the barge, and by utilizing pumps for raising the water required to separate the fine gold-bearing sand from the coarse, valueless gravel.

This brings the story of the evolution of the dredge up to the time of my last visit to Otago (1891), when the river-sands and sea-beaches of the south island were being worked by a force of fifty dredges, propelled by water, steam, and electricity. Since then the number has been decreased, owing to the lack of success met with by many of the dredging undertakings. This result is not to be wondered at; the machinery for raising the gravel out of the river-bed is good and efficient, but the devices employed to save the gold are imperfect. When this defect is remedied, the successful dredges, instead of being painfully few, will be very numerous. Space does not permit of a general discussion of this part of the subject; it can be found elsewhere.* For the present it will suffice to describe a typical instance.

The Dunedin dredge was at work on the Clutha at a place called Coal Creek, a short distance above Roxburg. It was one of the first dredges to meet with success and it is still, I believe, giving profitable returns. It is of the bucket-and-ladder type and is bilaterally symmetrical, one side of the machine being a duplicate of the other. It will therefore suffice to describe one side. An "endless" series of buckets, thirty-one in number, is kept going up and down. While the topmost bucket is being emptied the bottom-most is under the water of the river, being filled. Each bucket has a capacity of two cubic feet,

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"* Alluvial Mining in Otago," by the writer. Transactions of the American Institute of Mining Engineers, Vol. XXI.

and twelve of them are emptied per minute, so that 53 cubic yards, or 75 tons, are being treated every hour. The dredge as a whole has double this working capacity, since the other side is acting similarly. The buckets empty the gravel into a hopper or "holder," which feeds it into a perforated iron cylinder. This revolves slowly, and, being placed at a slight inclination, carries the large pebbles into an iron chute which ejects them into the river, while the finer sands which have passed through the apertures are sent over a table 8 feet long by 7½ feet wide. This table and its duplicate on the opposite side are covered with coarse cocoanut matting, which is intended to arrest the gold. Both tables have a slope of two inches per foot and discharge into a central table, 8 feet long by 4 feet wide, provided with riffles. From here the gravel falls into the river.

The gold, by the action of gravity, is caught upon the matting. The matting is washed at intervals in a tub. The latter becomes filled with the black iron sand and fine gold which are thus collected. The separation of the gold is effected by washing this material by hand in a miner's prospecting pan.

The working expenses are $1000 to $1250 per month, which inclues the wages of nine men and a foreman. The fuel bill is $150. The chief item of expense is for repairs, due to the wear and tear about the buckets.

The dredging of a river-bed in the teeth of a fast current is a work of much difficulty, especially when the two or three feet of gold-bearing wash lies upon an uneven bed and is covered by a valueless overburden of tailings many feet thick. The dredge has a much better chance when excavating "pay gravel" lying upon a "false bottom." Such was the case at Waipori, where the most satisfactory work has been accomplished. Instead of lying on a rocky and uneven bed, the golden material rests upon a layer of barren coarse sand, the true bottom being many feet deeper. The buckets of the dredge can get their lips underneath the "pay" and scoop it up successfully. It is like working with a shovel under water; unless you can get the shovel well under the sand you cannot prevent it from running off. A dredge, after all, is only a multiplied and modified shovel. Steam is usually employed in Otago to give the power necessary to drive the machinery of the dredges. Coal is not expensive. Nevertheless, the mountain streams afford every inducement to utilize a more modern method, to transmute the energy of the waterfall into that of the electric current. This is done by the Sandhills dredge. This dredge began to work at a place about 1½ miles below the generating station, but it has since worked its way above.

When the dredging fever broke out in New Zealand, in 1890, every river-bank and every sea-beach was thought to be richly gold-bearing. Some of the early successes met with on the Shotover were due to the luck and enterprise of a Chinaman, Sew Hoy. He did so much better than the colonists that one was tempted to put Bret Harte's question and ask whether the Caucasian was played out. Sew Hoy and his dredging enterprises are now a thing of the past, and the Mongol is again represented as digging for that which the white man has left, picking up the crumbs that fall off the Caucasian's table.

Certain places along the sea-beaches of the south and west coasts of the south island have been for many years worked by hand, and are known to be rich in spots. The prevailing winds have concentrated the titaniferous iron sand which carries the gold and which has been brought down by the rivers and distributed by the tides. In certain localities that concentration has progressed so far as to render exploitation profitable. At Waipapa, on the south coast, some successful work was done in spite of many difficulties. A centrifugal suction-pump was employed to gather up the material of the sea-beach, and stones exceeding 30 pounds in weight were successfully elevated by this method. The driven sea-mist does not hide the curving coast-line, but the wind has made ripples in the sands of the foreground and partially, at least, is illustrating the method by which the gold has been concentrated.

This dredge was able for a time to work at a profit sands from which it extracted only two grains per ton, or one part in fourteen millions. Nevertheless there can be no hesitation in saying that neither this nor any other of the dredges succeeds in arresting more than a fraction of the gold contained in the sand and gravel which they raise from the river or sea and return to it. The gold of New Zealand is not of the shotty, nuggety character common to most gold-regions; it consists of minute plates which, when their edges are turned, as must often happen when undergoing rough treatment by a dredge, become especially adapted to floating on water. The minuteness of the gold of many localities, particularly on the west coast, can be gaged by the fact that by actual count it requires 7000 particles to make up one grain in weight.

Is it to be wondered at that the cocoanut matting does not arrest it? No purely mechanical device can be expected to work successfully when working such an enormous quantity of unsized material. Chemical methods—the use of mercury—must be adopted and supplemented by a further sizing of the finer gravel which carries the gold.

At Waipapa plush of the finest quality was employed; elsewhere green baize has been tried. Cocoanut matting, apart from its cheapness, is admirably adapted for gold-saving by mechanical means. The fibrous rough surface gives opportunity for the gold to become caught. It is interesting in this connection to consider how primitive these gold-saving devices are. They were used under slightly different forms in the prehistoric era, when the Argonauts employed the fleece of the ram to arrest the gold of the river Colchis, and they are typified in the shaggy hides of wild beasts used by the aboriginals of many ancient gold-producing lands.

There is a fascination to the miner in the idea of working river-beds flowing through gold-bearing regions. Such river-beds seem to him to be paved with untold wealth, stored there by nature from her earliest day. There is an element of cold fact in the digger's dream, since the rivers have been the channels for golden gravel for long periods of time. River-dredging in the years that are coming is therefore destined to become of greater importance in contributing its share of the gold whose want is the pain of some, whose superabundance is the curse of others.

CEMENT AND CEMENT-TESTING.

By Spencer B. Newberry.

GREAT progress has been made within the last few years in the manufacture of hydraulic cement. In nearly every kind of construction this material finds application, and many difficult engineering problems have been solved by its judicious use. In hydraulic cement is found an effective means of binding together deposits of loose and insecure materials, thus making them capable of bearing enormous burdens. The great buildings of Chicago, resting upon a deep substratam of plastic clay, are rendered secure by massive foundations of cement and iron. In marine work and the improvement of rivers and harbors the uses of cement on an immense scale are well known. Recently a multitude of lesser applications of cement have been developed, such as its use as a foundation for asphalt and brick pavements, and in the manufacture of sewer-pipe, curbstones, tiles, and architectural ornaments. No modern house is complete without a good cellar-floor of Portland cement. Cement sidewalks also are replacing the more costly and less durable walks of flagstone ; in the city of Chicago alone nearly 8,000,000 square feet of cement walk were laid in 1892, requiring 200,000 barrels of cement. In cement we have the *essence of rock* in a portable and convenient form, requiring merely to be diluted with sand, moistened with water, and pressed into place to acquire in a few days the hardness and solidity of the best stone.

The cement used by the Romans consisted of a mixture of slaked lime with *pozzuolana,* a volcanic scoria which possessed the property of making ordinary lime hydraulic. This material and a similar substance from the Rhine, called *trass,* were the only hydraulic materials in use before 1756, when Smeaton built the Eddystone lighthouse. Smeaton made a comparative study of different kinds of lime in regard to their hydraulic properties and discovered that those limestones which contain a considerable proportion of clay yield lime of remarkable hardening qualities. By carefully selecting lime of this character he was able to build a firm and durable structure. Vicat, a French engineer, showed in 1818 that the cause of the hydraulic property is the combination of lime with clay, and, by burning mixtures of these materials, he succeeded in producing artificial hydraulic cement. Many deposits of limestone containing clay occur in England and France, and the manufacture of cement from this material gradually developed. It was later discovered that, in order to give the best results, the lime and clay must be mixed in very exact proportions and burned at a very high temperature. In this manner a product greatly superior to that made from natural rock was obtained, and to this the name Portland cement was given, from the resemblance in color of the hardened cement to that of the celebrated Portland building-stone. The manufacture of Portland cement has reached great magnitude in England, but within a few years Germany has taken the front rank in the quantity, and probably also in the quality, of her product.

Hydraulic cements are, therefore, compounds of lime with the silica and alumina of clay, and are made by exposing natural or artificial mixtures of carbonate of lime and clay to a high heat and grinding the product to powder. They owe their value for building purposes to their property of hardening, after mixing with water, to a stone-like mass.

If deposits of limestone could be found containing exactly the right proportion of clay, Portland cement could be made directly by burning such natural rock, but this hardly ever occurs. Either the limestone contains too little clay, in which case it is practically useless, or it contains too much, and, if exposed to the high temperature necessary to the formation of Portland cement, it fuses to a glassy slag destitute of hydraulic properties. In the latter case a low heat, just sufficient to drive off the carbonic acid of the limestone, will bring about a partial combination of the lime and clay, and a light-colored, quick-setting cement results. In this manner natural-rock cement—also called Roman, common, quick-setting, or hydraulic cement—is made.

Two kinds of cement may therefore be distinguished: (1) natural-rock cement, made from limestone containing an excess of clay, by burning at a low heat, and grinding to powder; and (2) Portland cement, made from an artificial mixture of chalk, marl, or ground limestone, with exactly the right proportion of clay, by burning at a white heat and grinding the resulting clinker to powder.

Portland cement is heavy, slow-setting, and greatly superior to natural-rock cement in strength and hardness. Owing to the greater labor required in its manufacture it is much more expensive than the common cement, and the latter is generally employed in this country for all purposes in which great strength is not essential. In Europe, however, the manufacture of natural-rock cement has practically ceased, Portland cement having proved cheaper to use, in spite of its greater cost, owing to the much higher proportion of sand that it will carry.

In the United States natural-rock cement is manufactured on an enormous scale, nearly 8,000,000 barrels of it having been made during the past year. The industry was first established at Rosendale, on the Hudson river, and in that neighborhood there are now seventeen factories, producing more cement than is made in any other locality in this country. The rock used in the Rosendale region is the limestone lying at the top of the Salina group, the outcrop of which extends along the Hudson river nearly to Albany, then turns westward, and is exposed at various points as far as Buffalo. This rock is a highly magnesian limestone, and contains a considerable proportion of clay. Cement is made from the same rock near Syracuse, and also very largely at Akron, Erie county, N. Y. The process of manufacture followed in the Rosendale region is very simple. The rock is quarried and burned exactly as in making common lime, continuous kilns being generally used. The calcined rock is of a yellowish or brownish color, and does not slake with water, the lime being chiefly in combination with the silica and alumina present. The burned rock is crushed and finely ground, and is then ready for use as cement. Other regions where natural-rock cement is extensively made are Louisville, Kentucky; Utica, Illinois; Milwaukee, Wisconsin; and Lehigh county, Pennsylvania. The product is known by various names, according to its place of manufacture, the best-known kinds being the Rosendale, Akron, and Louisville cements.

Natural-rock cement often shows remarkable hardening properties, but its chief defect is lack of uniformity. It is used on an immense scale for common purposes, as in the foundation of street-pavements and for building-mortar, and also in the lining of cisterns, reservoirs, and aqueducts. It has not sufficient hardening power to answer for sidewalks or flooring, and should not be used in foundations and masonry requiring great strength. The production of the natural-rock cement is so great that the price has fallen to a very low figure, much having been sold during the past year at not more than 25 cents per barrel, in bulk, at the works.

Portland cement, as already explained, is made by burning an artificial mixture of carbonate of lime and clay. Any pure form of carbonate of lime, such as chalk, shell-marl, or limestone, is available for the purpose, the latter being less employed on account of the cost of reducing it to powder. The great chalk-beds of England furnish an inexhaustible supply of excellent material for this purpose. In Germany large deposits of marl are utilized in cement-manufacture. This marl is a soft limestone, containing more or less clay, and is easily pulverized. In America the materials used hitherto have been limestone and shell-marl, the latter being a soft, fresh-water deposit similar to chalk. The only dangerous impurity likely to occur in any of these materials is magnesia, which, though harmless and probably advantageous in the manufacture of natural-rock cement, causes Portland cement to crack to pieces after long periods if present to the amount of 4 per cent. or more. Clay, the other ingredient of the cement mixture, is to be found everywhere, and almost any clay will give fair results if free from sand or gravel. The best clays for the purpose are those which contain a high proportion of silica, since much iron and alumina make the clinker too fusible and are said to yield a cement which is less permanent, especially when acted on by sea-water.

The first essential in the manufacture of Portland cement is that the materials shall be perfectly mixed. For this purpose they must be very finely ground, as the presence of a very small percentage of coarse material in the mixture will give rise to most dangerous defects in the product. Neglect to produce a perfect mixture is the source of almost all failures in making good cement, and the materials or method of burning are often blamed for faults in the product which are due solely to imperfect preparation of the mixture. It is probable that the great excellence of certain brands of cement is due to the perfection of this part of the process, more than to all other causes put together. In England the chalk and clay are mixed in wash-mills, and the mixture washed through fine screens and allowed to settle in basins. This process is expensive, and has been gradually replaced in Germany and elsewhere by the dry process of mixing, in which the materials are dried, powdered, bolted, and ground together. After mixing, the cement-material is usually molded into bricks for burning and dried.

A second essential is a correct adjustment of the proportions of carbonate of lime and clay. Each kind of clay requires a definite proportion of lime to give the best results. Cements usually contain from 60 to 64 per cent. of lime, according to the composition of the clay. The correct proportion of lime once determined, it will be found that an increase of 1 per cent. will give a cement liable to crack to pieces, while a decrease of 1 per cent. from the normal amount will give a product deficient in strength. To keep the mixture uniform, in practice, requires the greatest watchfulness and the assistance of a capable chemist.

The burning of Portland cement is usually carried on in intermittent vertical kilns. These are charged with the bricks of material and coke in alternate layers until full ; fire is lighted at the bottom and the charge allowed to burn out. The material is raised to a white heat, which slowly ascends to the top of the kiln. The filling, burning, and emptying of a kiln occupies about a week, and from 50 to 100 barrels of cement are obtained from a charge, according to the size of the kiln. After burning, the material is found in the form of "clinker," very hard and heavy, and of a greenish-black color. This is then crushed and ground to powder.

Within a few years continuous kilns have come largely into use for burning Portland cement. In these the fuel and material are charged together at the top, and the burned clinker periodically withdrawn at the bottom. These kilns save much labor, and yield a large output. The rapid destruction of the lining at the high heat employed and the adhesion of the clinker to the walls of the kiln are difficulties which have not yet been wholly overcome.

In the United States, the manufacture of Portland cement was begun at Coplay, Pennsylvania, in 1878. It is now carried on successfully at several points in Pennsylvania and Ohio and in the west, but the total output of American works does not supply more than one-eighth of the home demand for Portland cement, the balance being imported from England, Germany, and Belgium. Deposits of suitable material are not of frequent occurrence in the United States; the chalk-beds are located in the far west and south, at localities at present far removed from the chief markets; our limestones are chiefly highly magnesian and therefore unsuitable. Beds of shell-marl (or fresh-water chalk) of considerable extent are found at several points, however, and furnish the material at present chiefly used. The high price of labor, which makes up a large part of the cost of Portland cement, is doubtless a further reason for the slow development of the industry in this country.

We may now consider the chief uses to which cements are applied and the methods by which their quality may be tested. The process of manufacture is so simple that there appears to be every reason to expect a uniform and reliable product. We see constantly, however, cases in which work done with cement has utterly failed; sidewalks which have cracked and gone to pieces, floors which have expanded and pushed heavy walls out of line, and mortar which has weakened and finally fallen to dust after months or years. It is evident that there are hidden defects in some cements which may for a time escape notice, and that methods for the detection of these defects are absolutely necessary for protection against the failure of important work.

The chief qualities which make cement valuable are, perhaps, the following: setting and hardening properties, constancy of volume, permanence in water and in air, strength under tension and compression, resistance to wear, resistance to frost, impermeability by water, and adhesion to brick or stone. Let us now consider the chief uses to which cement is applied, and the special qualities which each use demands. It may be assumed that for all purposes rapid hardening properties and permanence in respect of strength and volume are essential.

I. Mortar and concrete: hardness, strength under compression.

II. Sidewalks and flooring: hardness, resistance to wear and frost.

III. Cistern, reservoir, and aqueduct linings: impermeability.

The testing of cements is a delicate operation, and much experience and judgment are necessary in order to secure even fairly accurate results. The methods of testing have been the subject of careful study by experts. In Germany, the requirements of the minister of public works* are recognized as a standard. In France, the requirements of the "Services Maritimes des Ponts et Chaussées" are generally followed.† In America, the subject of cement-testing has been carefully considered by a committee of the American Society of Civil Engineers, and their report ‡ will be found to contain full and valuable instructions. The German requirements are marked by simplicity, clearness, and good-sense, and probably represent the latest advances in the field of cement-testing.

We may now take up the chief qualities of cement which it is important to determine, the reasons for the failure of some cements to exhibit these qualities, and the methods by which such failure may be most surely and promptly recognized.

I. *Setting and hardening properties.* Cement, when mixed with water until plastic, gradually sets, becoming more or less hard and rigid. Natural-rock cement usually sets in a few minutes, or one-half hour at most. Portland cement requires a longer time, usually from two to eight hours. Cements containing a high proportion of clay, or those lightly burned, are more quick-setting than those high in lime or hard-burned. The time of setting is most easily determined by making a "pat" of the cement, about three inches in diameter and a half-inch thick, with thin edges, on a piece of glass about five inches square. The pat is placed in a tight box or under a damp cloth and tested from time to time, by light pressure with the finger nail, until no noticeable impression is made. The amount of water used greatly influences the time of setting, and different cements require different proportions of water to produce a given consistency. The German requirements prescribe the use of such an amount of water that several taps of the glass on the table or mixing-slab are required to make the pat spread out to the edges. The temperature of the room is also exceedingly important, as cement will set in a warm room in half the time, or less, required in a cold room. The room should be kept as nearly as possible at 70° F. during the mixing and setting, and the water used should be of this temperature. More accurate methods, using a needle 1-24 of an inch in diameter, carrying a weight of one pound, are also employed, but are unnecessary for practical purposes.

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* These may be found in a very useful book, "Der Portland-Cement und seine Anwendungen in Bauwesen" (Berlin, 1893), published under the authority of the Association of German Cement Manufacturers.

† See Candlot, "Cements et Chaux Hydrauliques" (Berlin, 1887).

‡ Transactions, November, 1885.

After remaining twenty-four hours in moist air, or at least over night, the pat is placed in water (kept at 70° F.), and the progress of the hardening noted. Good cement should harden rapidly and after one day in water should appear perfectly hardened, so that it cannot be scratched or scraped away by the finger nail. Good Portland cements are slow-setting and quick-hardening. There are many inferior cements which remain soft for several days, though they may become quite hard in time. The best cements are those which gain great hardness within a few days and show no falling off at long periods.

II. *Constancy of volume and permanence.* The question of the soundness and lasting-qualities of cement is perhaps of greater consequence than any other, as the stability of work done with it depends entirely upon this quality. Some cements, though hardening well when first used, show after weeks or months a tendency to swell or crack, often lifting great masses of masonry by their expansion, and after a longer time are found to have fallen completely to powder. The cause of this alarming defect is the presence of free or imperfectly combined lime in the cement, due to too high a proportion of lime in the raw material, or more often to imperfect mixing of the ingredients. The presence of a small percentage of coarse particles of carbonate of lime in the mixture will infallibly produce an unsound cement. This fault is exceedingly liable to occur, since the perfect grinding and mixing of the raw materials are a matter of great difficulty and expense. Free lime in cements slakes only after long periods, and in slaking expands and causes the hardened cement to crack to pieces. The presence of more than 4 per cent. of magnesia in Portland cement is supposed to produce the same effect. So far as is known, the presence of free lime (or magnesia) in cement is the sole cause of its failure to maintain the strength and hardness at first acquired. As this fault is always the result of expansion, it may be said that cements of constant volume will prove permanent in use.

The usual method of recognizing a tendency to expand or crack is the pat test already described. Two such pats should be made and allowed to set; one is then placed in water and the other kept in moist air. The first evidence of bad quality is the loosening of the pat from the glass, which generally takes place, if at all, within one or two days. Bad cement will also show fine radical cracks on the thin edges of the pat, which will also curve up more or less at the edges, presenting a saucer-like shape, and will often become covered with a net-work of cracks, like alligator-leather. These appearances are usually more marked in the pat kept in moist air. Good cement will remain firmly attached to the glass for two weeks at least, will harden well within two or three days, and will show no cracks, even after a month or more in water. Among the many tests which may be applied to cement, there is none which gives so sure and complete an indication of its quality as this simple pat test on glass; time of setting, hardening qualities, and permanence are thus determined in a single operation.

The hot test, for the quick detection of any tendency to expand or crack, has come into extensive use within the past few years, and has proved to be of great value.* The test consists in exposing a pat of cement, prepared on glass as described above, to the action of steam for about three hours; then allowing it to lie in boiling water for an equal time. The presence of a very small proportion of free lime will cause the pat to swell and crack under this treatment, and sometimes to fall completely to powder, while perfectly sound cements will remain on the glass and harden well, showing no sign of cracking. The Association of German Cement-makers has refused to endorse this test, claiming that it is too severe, and that its use would condemn many cements which prove perfectly sound in practice. There is, however, a very close connection between cracking under the hot test and failure of the cement after long periods, and there can be no doubt that both result from the presence of free lime, chiefly due to imperfect mixture of the materials. It is certain, also, that proper care in manufacture will produce cement which will stand the hot test perfectly, even when very fresh. The use of the hot test is a great safeguard to consumers, as a cement which stands this test well may be relied upon to prove perfectly sound and permanent for all uses, in water as well as in air.

After prolonged seasoning or exposure to air, most cements which show a tendency to crack when fresh will be greatly improved, and may become perfectly sound, owing to the gradual slaking of the free lime present. It is not well, however, to rely too much on this method of cure, as the final destruction of the work is often only postponed by this process. Such seasoned cement will rarely stand the hot test and becomes more dangerous, owing to the fact that its unsoundness may escape detection by the cold pat tests usually employed.

III. *Strength under tension and compression.* Tensile strength is determined by making up briquets of the cement, both neat and with sand, and pulling them apart on a testing-machine after a certain period in water. In Germany the only test officially recognized is that of cement with three parts of sand, broken at twenty-eight days. In this country neat tests at shorter periods are also generally made. The results of these tests depend to a surprising degree on the conditions under which the briquets are made, and no one can hope to obtain uniform or just results without practice and careful observation of many minute precautions.

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* Full directions for making this test have been given by Captain W. W. Maclay, Transactions of the American Society of Civil Engineers, 1892.

The temperature of the room in which the briquets are made, and also that of the water used for mixing and that in which the briquets are allowed to lie, should be kept as nearly as possible at 70° F. The effect of this is seen especially in the results at short periods. A sample of cement which shows a strength of 150 pounds after twenty-four hours, when the briquets are made and allowed to set in a warm room, will generally show less than 50 pounds if kept in a room near the freezing-point.

The amount of water used should be such as to produce a uniformly plastic mortar. Different cements require different amounts of water; for quick-setting natural-rock cement at least 30 per cent. of water will be necessary, while with Portland cement from 22 to 25 per cent. will be found sufficient. The use of more water than is necessary to produce a fairly plastic mortar greatly weakens the briquets.

The manner of mixing the mortar greatly affects the results, as the longer the mixture is worked with the trowel, up to a certain point, the greater strength the briquets will show. The cement and water should be mixed on a slab of slate or marble, and worked thoroughly with a trowel for at least five minutes. A good plan is to rub enough mixture for each briquet in a large porcelain mortar for a few moments. If this practice is adopted it should be uniformly adhered to.

The molds should be slightly oiled (or soaped) on the inside. The mortar is then pressed into them as firmly as possible with the thumbs, rubber thumb-caps being used to protect the hands. The consistency of the mortar should be such that a firm pressure can be used. Pounding the mortar into the molds will give higher breaks, especially if only 18 to 20 per cent. of water be used, but is not to be recommended, as uniform results cannot be obtained by this method. The surface is smoothed off with the trowel, and should appear wet and plastic. The molds are then turned over, filled, and smoothed off on the other side. The briquets are then placed under a damp cloth and left until set before the molds are removed. With quick-setting cement two hours will be sufficient; with Portland cement the molds should not be removed until the next day. In all cases the briquets should be left for twenty-four hours in air before placing in water.

Sand tests are usually made with one, two, or three parts, by weight, of sand. With three parts of sand, water to the amount of 10 per cent.

of the total weight of cement and sand will be found to give the best results, and this proportion is specified in the German requirements. The character of the sand used greatly affects the results. In Germany a natural sand from Freienwalde °/Oder, passing a sieve of 20 meshes to the inch and remaining on one of 30 meshes, is recognized as the standard. In the United States, crushed quartz of the above fineness is generally used, as recommended by the Society of Civil Engineers. This is made by several manufacturers of sandpaper. Ordinary building-sand will generally be found to give rather higher results than the standard sand, as the varying size of the grains leaves less space to be filled with cement. In making sand briquets, thoroughness of mixing is even more essential than in neat tests. The German requirements specify that the mixture of cement, sand, and water shall be strongly worked for five minutes. The writer lately tested a cement with three parts sand and found that, after working the mixture one minute, a tensile strength of 87 pounds in seven days was obtained, while the same mixture, strongly worked for five minutes, gave a strength of 240 pounds in the same time.

In making sand briquets a certain amount of pounding is necessary. The German requirements recommend the use of an iron spatula weighing 250 grams. Uniform results may generally be obtained by filling the molds above the top, laying on a piece of wood, and gently pounding with a hammer or mallet. In actual work the proportions of cement and sand are always measured (usually by shovelfuls), not weighed. As cement is 50 per cent. heavier than sand, allowance must be made for this in estimating the value of various mixtures for practical purposes. One part of sand by weight is equal to 1½ parts by measure. Briquets of 1 cement to 3 sand therefore represent the strength which may be obtained in practice from mixtures of 1 cement to 4½ sand, by measure.

In judging the results of tests of tensile strength it should be remembered that steadily increasing strength at long periods is better proof of good quality than high results during the first few days. The behavior of the cement in the pat test and hot test should also be considered in this connection. Cements which are very high in lime, and even those showing a slight tendency to expand and crack, often show astonishingly high breaks at one day and at seven days. This appears to be due to a condition of strain, and is nearly always followed by falling off in strength when tested at twenty-eight days and longer periods.

Natural-rock cement, neat, will generally show 50 to 75 pounds in seven days, and 100 to 200 pounds in twenty-eight days. Good Portland cement, neat, will show from 100 to 200 pounds in one day, 400 to 600 pounds in seven days, and 600 to 800 pounds in twenty-eight days. With three parts sand, Portland cement should give at least 100 pounds in seven days, and 200 pounds in twenty-eight days. The German requirements specify that cement with three parts sand shall show a strength at twenty-eight days of 16 kilograms per square centimeter, corresponding to 227 pounds per square inch.

Compression tests are rarely made in America, owing to the rather costly apparatus required. Such tests are, however, of great value in determining the suitability of cement for important work. In general it has been found that the results of compression tests, both neat and with sand, are about ten times as high as tensile tests on the same section. Natural-rock cements give generally relatively lower results in compression tests.

IV. *Resistance to wear, impermeability, etc.* The tests for time of setting, constancy of volume, and strength under tension and compression are the only ones generally made, since these qualities vary greatly, even in different samples of cement of the same make. The other essential qualities of good cement, such as resistance to wear, resistance to frost, impermeability by water, and adhesion to brick or stone, are not liable to great variations, and it may be assumed that any cement which stands the usual tests will give satisfactory results in all other respects.

Tests of the comparative power of different cements and mixtures of cement with sand to resist wear have been made by Professor Böhme, head of the royal testing-station for building materials in Berlin. His apparatus consists of a rotating cast-iron table sprinkled with emery powder, upon which cubes of cement are ground for a given time under constant pressure. Neat cement is found to be greatly inferior in wearing qualities to mixtures of cement with sand, being, in fact, about equal to a mixture of 1 to 3½ parts. The best wearing qualities are shown by a mixture of 1 part cement to 1 part sand (by weight) ; practically equal results are obtained with a mixture of 1 : 2. These facts have an important bearing on the use of cement for sidewalks and flooring. The greatest fault met with in sidewalk work is the occurrence of long irregular cracks across the blocks. This fault is usually attributed to the poor quality of the cement or to frost, but it is solely due to slight shrinkage of the cement in hardening, and occurs with the best and hardest cements when the proportion of sand employed is too small.

As for resistance to frost, little or no hardening takes place at temperatures below freezing, and partially hardened cement, saturated with water, is liable to suffer much in strength by being frozen. After thawing, however, the hardening proceeds again, and in most cases no serious results from freezing are apparent. The addition of salt to the mortar, often practiced, is harmless, and in some cases may be of value. The chief point to be observed in using cement in winter is the sparing addition of water. In fact, an excess of water is in all cases injurious, as the strength of the work is greatly weakened by it. Probably in nine cases out of ten masons add far more water than they should, from either carelessness or a desire to avoid the greater labor of working less fluid mortar. The best results are always obtained by making a mixture of cement and sand not wetter than moist garden earth. No water should be visible until the mixture is well trowelled or pounded. If this precaution be observed, cement work may be carried on in the coldest weather without bad results.

V. *Impermeability*. Cement is extensively used as a waterproof material, especially in lining cisterns, aqueducts, and reservoirs. The impermeability of cement-mortar increases greatly with age, so that comparatively porous mixtures will become quite dense in time. For linings which are to be immediately waterproof not more than one part of sand (by weight) to one of cement can safely be used. A mixture of 1 cement to 2 sand will, however, prove impermeable after the lapse of a few weeks. The addition of slaked lime to the mortar greatly increases its density, and also increases the strength of mixtures poor in cement. In concrete work a mixture of 1 part of lime, previously well slaked, 1 part Portland cement, and 6 parts sand will be found to give as good results as 2 parts cement to 6 of sand, the lime thus replacing half the cement without causing loss of strength. Used in this manner Portland cement will be found much cheaper than the natural-rock cements for ordinary uses. For waterproof linings a mixture of 1 part cement, ½ part slaked lime, and 3 parts sand, or even 1 cement, 1 slaked lime, and 6 sand, will be found sufficiently impermeable. It has also been found that the addition of slaked lime to cement-mortar greatly increases its adhesion to brick or stone. Masons often object to using mixtures of cement with three or more parts sand as mortar for brickwork and masonry, on account of its working "short" under the trowel. Increasing the proportion of cement is extravagant and unnecessary. The objection can be overcome by adding one part of slaked lime, which will make the mortar "fat," plastic, and easy to work.

THE PINE INDUSTRY IN THE SOUTH.

By George L. Fowler.

THE lumber industry in the southern United States, ranking in importance with that of the states of the north, possesses some features which distinguish it from the methods of preparing lumber for market elsewhere. The readers of this Magazine who followed Mr. Parker in his account of "The Northern White Pine Industry" last month may be interested in a presentation of some facts relative to the longleaf yellow pine, known also as the Georgia pine, which is widely regarded as the most desirable wood in the market for a great variety of purposes.

The size to which this tree grows enables the sawyer to cut sticks of almost any desired size or length, and large quantities of the wood are consumed in the manufacture of car-sills and bridge timbers, while the smaller sizes furnish a favorite class of wainscoting, flooring, and ceiling. Strange as it may seem, there are no trustworthy statistics of the amount of this timber standing or in sight, or even of the annual output. Various estimates have appeared, but those who are best informed agree that not even an approximation has ever been made. This is due to the fact that there is no lumber exchange in the south charged with the collection and verification of such statistics, and that there are a great number of small sawmills of whose output absolutely no record is kept. Perhaps as near an approximation as can be made is that of 400,000,000 feet per annum of the Georgia pine.

Very little rafting of logs is done in the south, so that there are no large boom companies handling lumber, with records that would serve as a basis for approximate statistics. The pine grows on high sandy soil, away from the streams. Although the trees stand comparatively near together, the large or "saw" trees are so few and far between that it requires careful selection to get more than 8000 feet of lumber to the acre, while the probable average is nearer 5000 feet. The foliage is scant and the sun streams through as in an open grove, and the ground is covered by a thick growth of rank wire-grass which serves as the sole means of subsistence for thousands of cattle and hogs that roam through the woods, with even less attention than that bestowed upon the herds on the western prairies.

The first step taken in the manufacture of Georgia pine lumber is to turn over a block of the trees to the proprietor of a turpentine distillery. He "boxes" and "scales" the trees. That is, he cuts in one side of the tree a "box" which will hold about a quart of sap, and then slashes away the bark to a height of four or five feet, running up to a V at the top. The resinous exudations from the sappy portions of the wood run down into the box and are thence gathered for distillation into turpentine and resin. The trees are usually allowed to remain in this condition for three years, the product of the first year being the most valuable. Lumbermen do not regard this process as injurious to the tree in any way, either to its subsequent life or to the value of the lumber to be cut from the trunk. So the process goes on; the trees stand for three years bearing their own tombstones and, indeed, presenting a very strong likeness to a graveyard in a grove.

At the end of the three years of "turpentining," the axemen go into the woods and the more rapid work of destruction begins. Cutting is continued throughout the year, as the season during which the trees are cut makes little or no difference in the quality of the lumber. This work is done usually with the axe, as there are few woodsmen in the south who use the saw for felling trees. After the tree is upon the ground, nothing is done in the woods save to lop off the branches and cut off the top. The cutting of the trunks to suitable lengths is usually done at the mill, where logs are selected to fill certain "bills." The peculiarity of the Georgia sawmill is that most of its orders are for "bill" stuff, which may vary from twelve feet to sixty feet in length, and that very little is cut into boards and standard sizes. When the trunk is down the teamster is on hand with a four- or six-horse team of mules and a pair of heavy wheels, averaging about seven feet in diameter, with tires seven or more inches wide. A heavy pair of grip-tongs hangs from the axle in such a way that they may be lowered and opened by raising the tongue. As the tongue is brought down, the tongs grip the log in the middle of its length and raise it from the ground. Strong chains then secure the tongue to the log, the team is hitched on, and the log is started toward the mill.

The ease and certainty with which the negro drivers handle their teams is an interesting feature of this woodland work. Amid a shrieking, yelling lot of teamsters, creating a bedlam, each mule seems to know his own driver's voice and will stand stock still until ordered by him to move. When hauling, the driver rides the near wheel mule and his three methods of control are the loud cracking blacksnake whip, his voice, and the single rein leading to the bit of the near leader. A steady pull on this rein will turn the team to the left and a series of jerks will send it to the right. With this alone, and without any holdback or brake other than the light trailing of the rear end of the stick, the load is taken up and down hill, worming its way between trees and stumps, rarely hitting anything, and is finally deposited exactly where it is wanted, either at the mill or at the runway beside the logging-road built out into the woods. On the return for the load, no pains is taken to avoid any obstruction, and the mules and cart are driven over logs and stumps with a surprising abandon.

The smaller concerns, whose capital and output are limited, haul the logs directly to the mill, while the larger mill-owners have built logging railroads for many miles into the woods. The construction of these logging-roads is of a superior character. The hills rarely present very steep grades, so that the ties are laid practically upon the natural surface of the ground, which gives a roadway full of sags and crests, necessitating careful work on the part of the locomotive engineer to avoid breaking in two. The cars used are low, flat cars, from thirty to thirty-four feet long, mounted on bogie trucks and coupled with a link thirty-five feet long. This link is made of a stick about eight inches in diameter and shod at either end with an eye for the link-pin. In this way logs of eighty or even ninety feet in length can be carried very easily on a single car. They are loaded in a single row across the platform and are rarely heaped up.

In describing the southern sawmill, it seems best to take one equipped with the best and most approved machinery and doing business upon a large scale, rather than the smaller mills where the output is meager and the plant of an antiquated pattern. These small mills are scattered throughout the southern part of Georgia and are worked with forty-inch saws and a rack or friction feed at a speed but little superior to the vertical saw of early days. They eke out a precarious livelihood for their owners, principally because business methods are as lacking as improved machinery, and the owners of such mills stand, by the score, on the verge of bankruptcy. Of the forty-seven operating sawmills reported along the line of the Georgia Southern and Florida railroad the daily capacity ranges from 5000 to 80,000 feet of lumber per day, the average being about 16,000 feet, and these figures may be taken as the average for the remaining mills of this section, of which there are an unknown number. While the facts presented in this paper relate especially to the lumber industry as conducted in Georgia, it may be added that the same conditions prevail in portions of the neighboring states of North Carolina, South Carolina and Alabama, in which sections of the pine area are also to be found.

The logs reach one of the better class of mills on the cars and are rolled off upon the skidway in about fifteen minutes by men with cant-hooks, working in gangs of three or four. On the skidway they are sawed into proper lengths by hand power, and thence loaded upon a heavy car which is hauled up the inclined log-run into the mill. The machinery is usually in the second story, which gives ample room for the engines, shafting, sawdust-conveyors, and belting beneath the

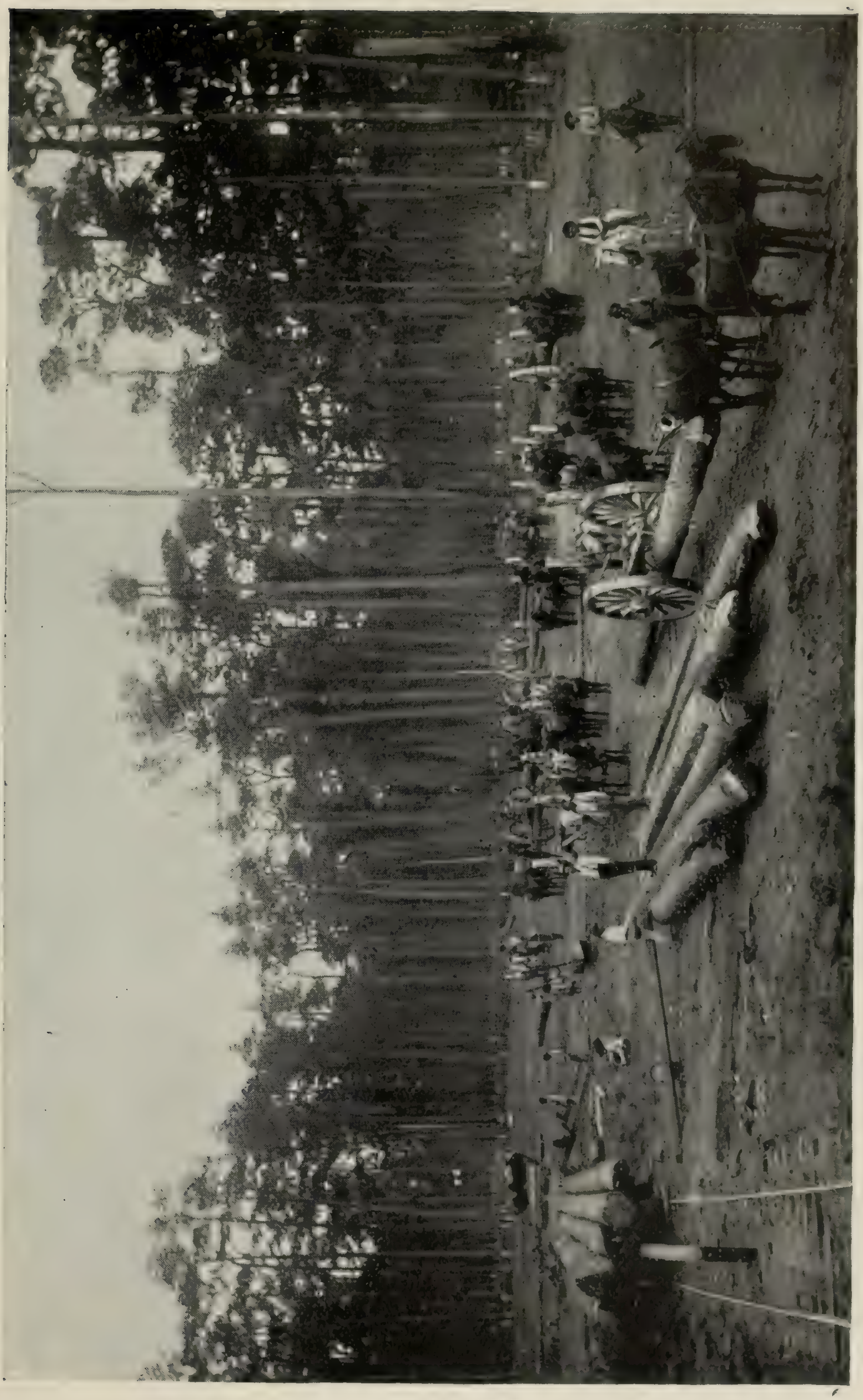
A TYPICAL GEORGIAN PINE-FOREST, BEFORE CUTTING HAS BEGUN.

floor. The engine used for driving the saw is usually of the plain slide or roller-valve type, with no pretense of close adjustment for speed or economical use of steam, for the economical use of the steam is the last thing that the mill superintendent seeks to accomplish. He cannot even burn all his sawdust under the boilers, to say nothing of slabs and edgings. The boilers are of the return multitubular type and are run with the safety-valves blowing, and supply steam for the 100 to 150 horse-power engine which drives the main circular saw.

This saw is *the* saw of the mill and cuts everything from the heavy bridge timber to the one-inch board. It is usually sixty inches in diameter and is run at a speed of 800 revolutions per minute. It is belted direct to the main engine and can only be stopped by stopping the engine. The teeth of the saw are swaged out to cut a kerf of five-sixteenths of an inch.

The log-carriage, which is entirely independent of the saw, runs on a truncated, inverted V-shaped track and is carried on wheels about ten inches in diameter. There is a single headblock at one end, operated by a man who rides on the carriage, and has a reciprocating motion given to it by a pair of engines with cylinders nine inches in diameter and sixteen inches stroke, coupled on the quarter and driving a grooved rope drum. As the engines are reversible it is evident that, by passing the rope around pulleys outside the carriage travel, the latter can be pulled up in either direction. The advancing or "feed" speed of this carriage is made to vary according to the size of the log being cut, and ranges from three to eight inches per revolution of the saw. This corresponds roughly to a cut of from 300 to 800 feet per minute. One who has not seen one of these mills in operation can have no realization of the rapidity with which the work is done. A log twenty feet long will have a slab or board taken off in about the same length of time that the wood-sawyer will cut off a four- or five-inch stick with a horse treadmill as a motive power. On the return the speed of the carriage may be said to average about 1500 feet per minute. The circular is then *the* saw of the mill. Gang-saws are not used because they are adapted only for the economical sawing of boards, and cannot be used to any advantage on orders calling for a miscellaneous assortment of special sizes.

Square timber, joists, scantlings, and ordinary "bill" stuff leave the circular saw ready for shipment, but boards are subjected to further treatment. The slabs, when they fall from the log, are thrown upon a conveyor by which they are carried to a saw that cuts them into suitable lengths for being manufactured into lath, or they are carried away and dumped from a high trestle into a pit, where they are burned at the rate of millions of feet every year. Such a trestle may be seen



BANKING GROUND IN A GEORGIAN PINE FOREST, ALONGSIDE THE LOGGING-TRACK.

near the right of our view of the mill at Richwood, Georgia, shown on the opposite page.

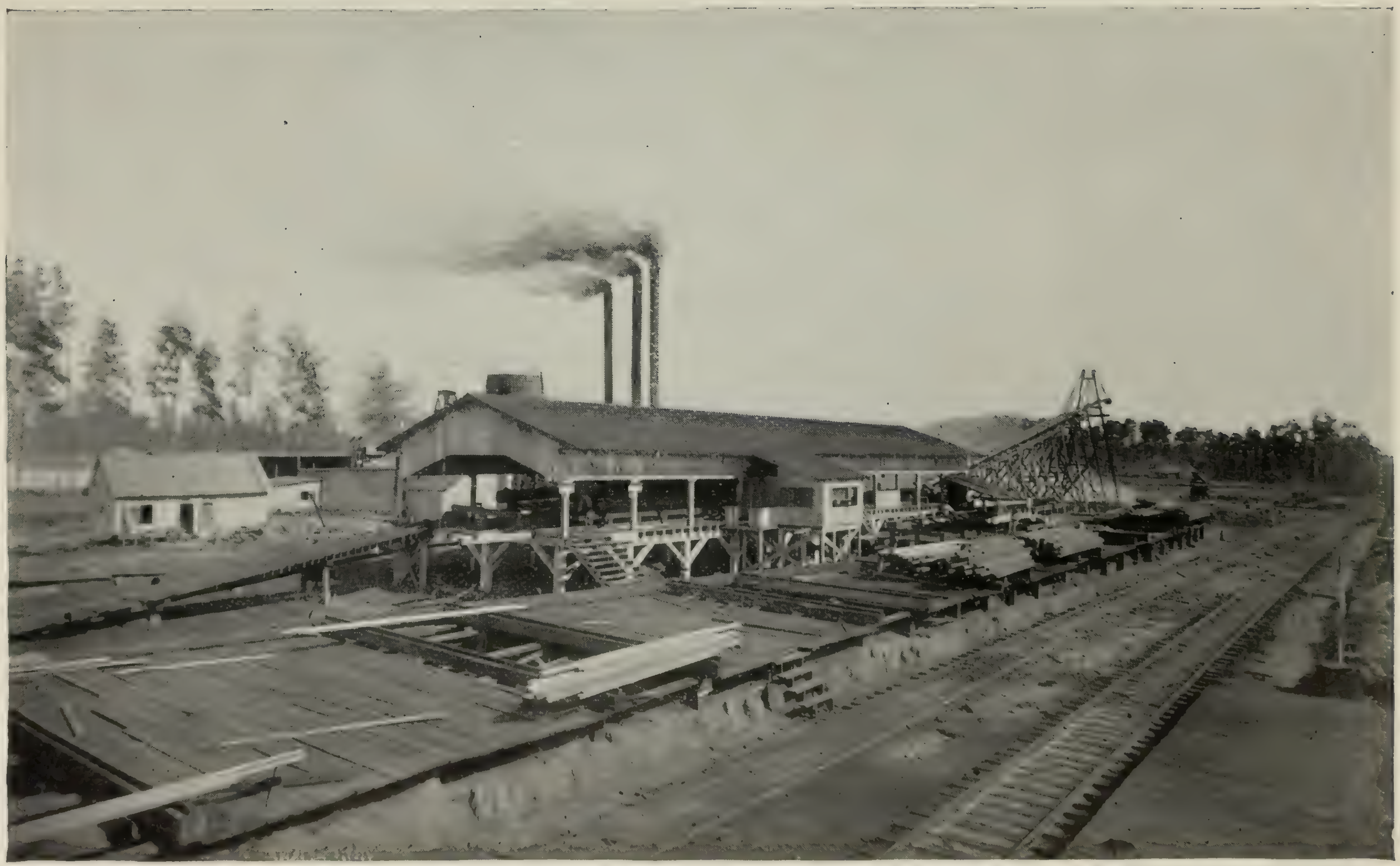
The boards are thrown, as they are cut, upon "live" rollers,—*i. e.*, rollers that are kept in motion,—and carried along to the edger. Sometimes, however, boards are cut from logs forty or fifty feet long, so that when anything comes along that is more than eighteen or twenty feet in lengrh, the man in charge stops the rolls when the board reaches the proper point and raises a "jump" saw through the board, cutting it into suitable lengths for handling. This "jump" saw is constantly in motion and is raised by a steam-cylinder whose piston-rod is attached directly to the boxes carrying the saw arbor. The pressure of the foot upon a lever admits steam to the bottom of the cylinder and the piston is raised. The removal of the foot opens the valve, the steam is exhausted, and the saw drops out of sight.

The "edger" is merely a saw-table with two saws, one stationary and the other movable. It is used to cut off the bark that may have been left upon the board by the circular saw. The object of the movable saw is to cut boards of varying widths without wasting the lumber.

From the edger the board passes to the "trimmer," which trims off the ends of the board square with the edges and leaves it the standard length, say twelve or twenty feet. When the board leaves the trimmer the work of the sawmill proper is done, and the lumber is ready for the dry-house or for shipment. If the mill skidway were empty and everything in readiness, the average working would carry a log twenty feet long and twenty inches in diameter up the incline, put it on the saw carriage, cut it up into say 2 × 4″ bill stuff, edge and trim the boards, and clear the mill of its presence in about ten minutes.

The natural auxiliaries of the sawmill are the planing-, lath-, and shingle-mills. The first is a mere duplicate of what may be found in every town. There are "surfacers" for smoothing the sides of the board, matchers for tongueing and grooving, and saws. There is nothing about them peculiar to the Georgia lumber industry except that occasionally a mill is found with a planer for dressing large square timbers. The lath- and shingle-mill can be operated to advantage only in direct connection with the sawmill, whose waste they serve to put into useful shape. A lath-mill consists of a cut-off saw for cutting the slabs to the proper length ; a rip-saw for sawing these lengths into thicknesses the width of the lath ; a gang-rip-saw for cutting the lath ; and a bunching-machine for shaping and holding the bunches while they are being tied with marline. Four men and three boys serve to do the work, and they will make from 25,000 to 35,000 lath per day, according to the size of the slabs.

The shingle-mill uses the waste in the shape of the butt ends of logs,

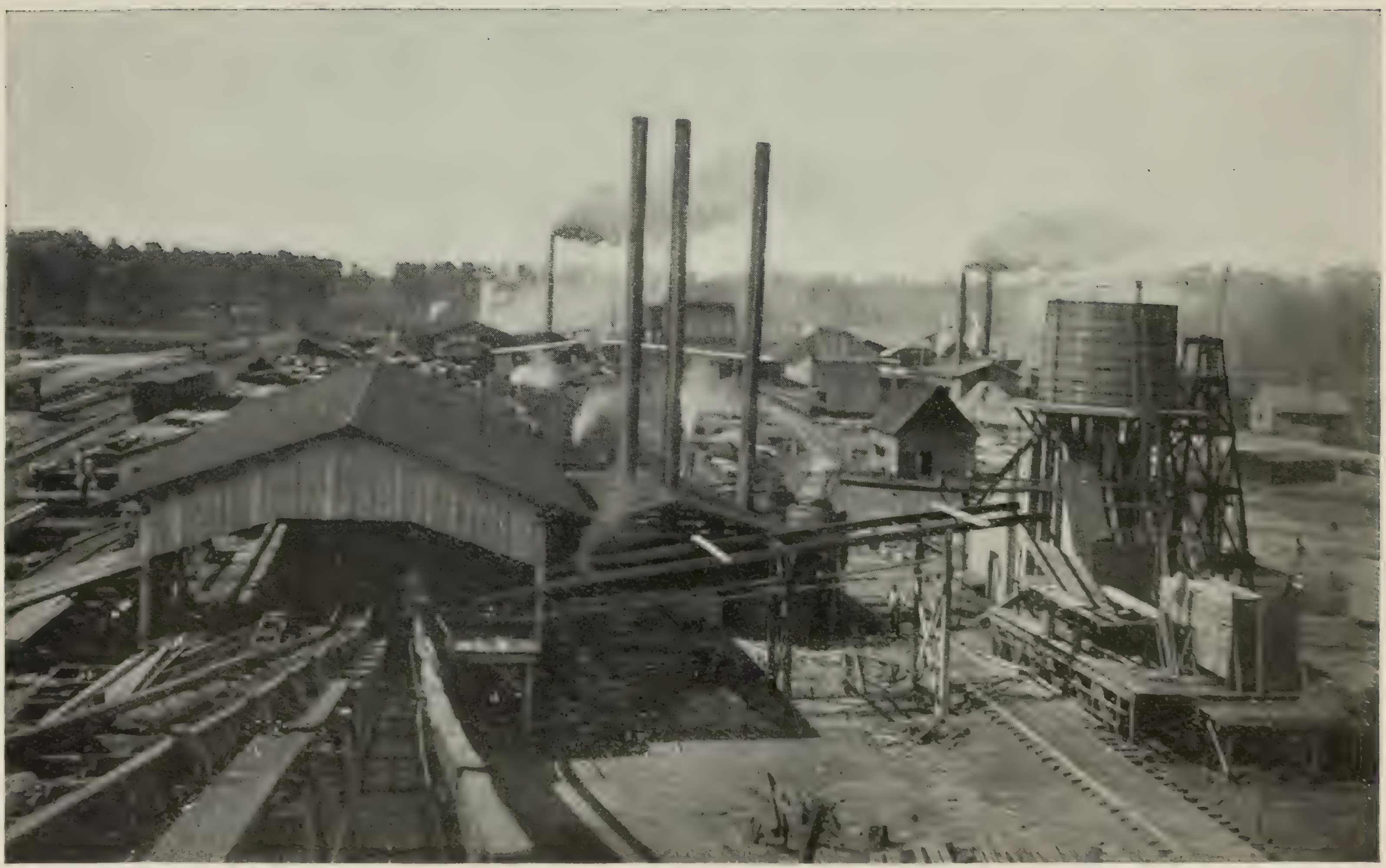


MAIN SAWMILL OF THE RICHWOOD (GEORGIA) LUMBER COMPANY.

or ends sawed off from the square timber, and its machinery consists of a cut-off saw, a rip-saw, a shingle-saw and two bunchers, with a conveyor from the shingle-saw to the bunching-table. Shingle-saws are made with from one to ten "blocks"; that is, they cut from one to ten shingles with each complete stroke of the saw, but the capacity does not increase with the number of blocks. Two-block machines are deservedly very popular on account of the simplicity of their construction and their easy action. They will cut about 35,000 shingles in ten hours.

We have now followed the wood from the tree to the market, and by far too small a percentage reaches this latter point. Waste is everywhere apparent, and even the most careful managers acknowledge that their wastefulness is extreme. High railroad freights and long distance from markets render it unprofitable in the south to engage in the manufacture of many small articles that might readily be made from slabs and edgings. But there is another source of waste for which absolutely no excuse exists, due to slack business methods and ignorance of the capacity and capability of modern wood-working machinery. There is extravagance in the thickness of the lumber used for certain purposes. For example, what is known as a bevel-edge weather-board is one-half inch thick on one edge, one-quarter on the other, and six inches wide. The rough stuff ordinarily furnished for this is six inches wide and 1¼ inches thick. This allows for re-sawing and finishing two surfaces. The allowance is one-quarter inch for the kerf of the saw, and one-eighth of an inch for each smoothing finish, whereas one inch in thickness is ample, allowing one-eighth of an inch for the kerf, while three sixty-fourths should be enough for finishing. This would leave the rough stuff with a total thickness of less than an inch and effect a saving of over 20 per cent. Mill-owners of the first grade are ready to acknowledge this wastefulness and point it out, but it seems to be inbred in the bone and very little is done to check it.

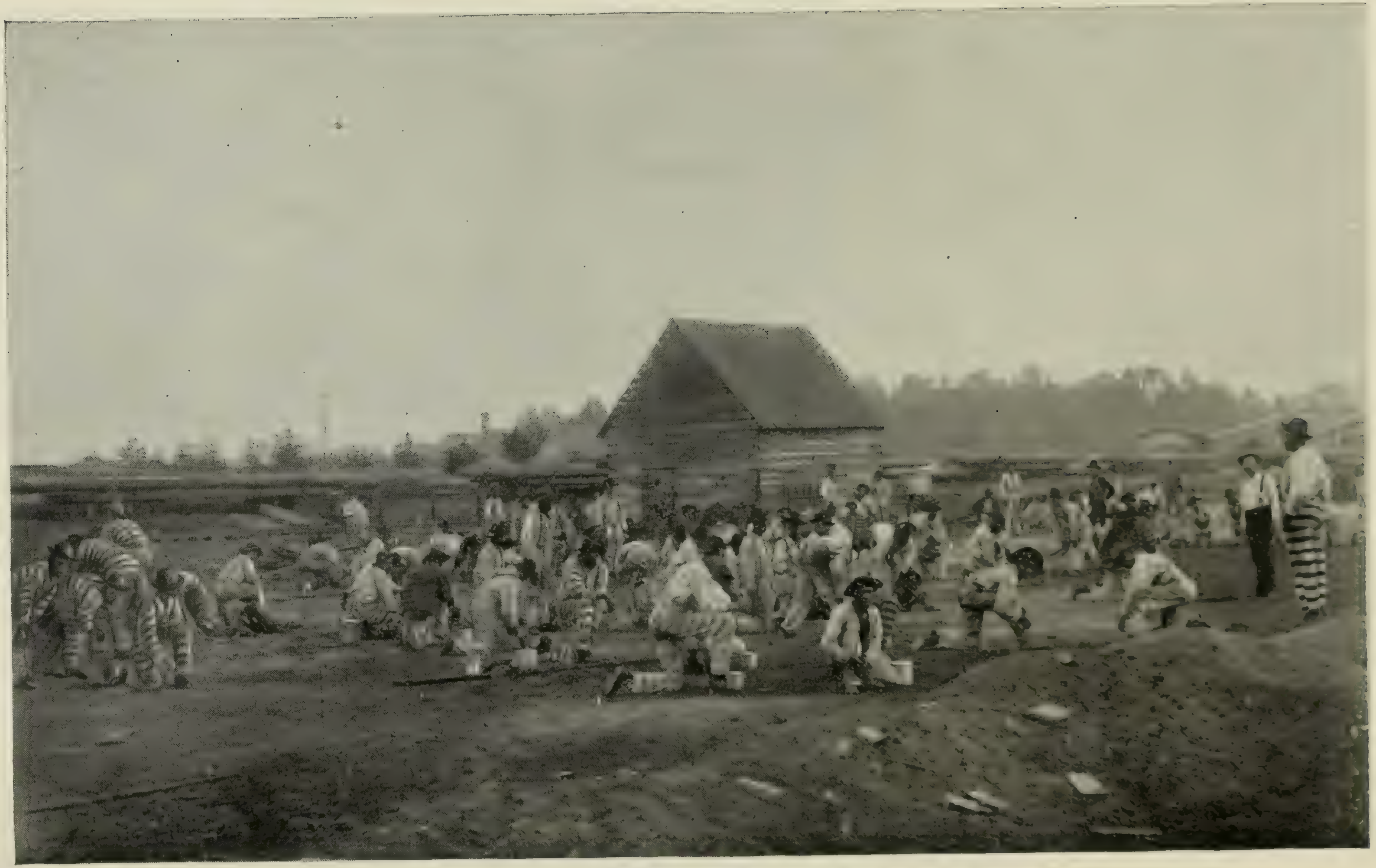
No description of the Georgia pine industry would be complete without a reference to the labor element. It has been customary for outsiders to consider the southern laborer as slow, lazy, and shiftless, but no stranger could enter one of these mills or pass a day in the woods without being surprised and charmed by the vigor and rush with which the work is performed. The carriages fly with the speed of express trains, and the sharp tang of the saw is unceasing; or, if you are in the woods, the cries and shouts of the drivers and cutters ring upon the ears in an unending chorus. The very animals seem infected with the rush and the drive, and the liveliest western community under the influence of the most powerful of "booms" could not be more active or wide-awake. Work has become an instinct; the laborer knows but



Convict sentry-boxes in background. Dry-house. Tanks for feeding boilers

Slab-conveyor to burning-pit. Storehouses. Logging-road.

ANOTHER VIEW OF THE RICHWOOD LUMBER COMPANY'S SAWMILL.



GANG OF CONVICTS AT A GEORGIA SAWMILL PREPARING FOR WORK.

[Wrapping about their ankles the chains with which they were fastened together while being brought from the camp to the mill-ground.]

four conditions,—eating, sleeping, working, and, after pay-day, a carouse or absolute idleness. Negro labor, which is the sole dependence, is better, more reliable, and therefore cheaper than the white, but, as the laborer has no mental resources, and as he is cut off from the pleasures of his city brethren, his discontent is quickly manifested when the hours of idleness are upon him.

A curious story of a strike is told at one of the mills. The hours of labor are long,—from dawn to twilight. In the winter the hours are fewer, but in summer the saws are buzzing and the whole community alive and at work before the sun has touched the tree-tops. A northern foreman of philanthropic principles took charge of a certain mill, and sorrowed within his heart for the poor fellows wearing out their lives with the cant-hook and saw. So he decreed that from 7 A. M. to 6 P. M. should constitute the labor of a day. There was a murmur in the camp and in two days there was a general strike. Called upon for reasons, the spokesman stated the case of the men: "We all jus' doan like dis yar gwine ter wuk at seben o'clock. Wha's de use ob sittin aroun' fer two hours in the mawnin' fo' gwine ter wuk? We jus' ain' gwine to stan' it, dat's all." So the strike was declared off by the superintendent agreeing to allow all hands to go to work at dawn and keep at it as long as they could see.

Convict labor cuts a prominent figure in Georgia. The convicts are "farmed out" by the state to mill-owners and work side by side with the free hands. Of abuses there are undoubtedly many, but when one compares the comfortable quarters of the convicts, their healthy, palatable food, the care given to them in sickness, and the *tout ensemble* of their surroundings, with the barren quarters, scanty food, and hardships of the free laborers, one is tempted almost to cast his lot with the convicts. The negro laborer is a child in his improvidence and helplessness; he spends his wages before he earns them and is always poor. I walked one day from a convict-camp, where the men were well housed and fed, to the free quarters, where squalor and poverty were so apparent as to be heartrending. I saw one man and his wife living in a house in which there was absolutely no furniture. Their meat was roasted on a spit and their vegetables cooked in the ashes. When they went out they carried all of their earthly belongings with them. But the climate is so warm and the air so pure and fragrant that of actual suffering they seem to have but little.

The convicts are treated differently. To quote a mill-superintendent: "We look upon them as animals bought to do a certain amount of work, and for which we pay hard cash. If they are sick we are responsible, and the pay goes on; therefore, in pure self interest, we feed them well, not luxuriously, but healthfully and in abundance; we house them well and keep them clean, and our hospital is rarely occupied.'' There is no maltreatment ; it is a criminal offence for any but the captain to strike a convict, and this is a duty he cannot delegate to another. To be sure, obstreperousness is punished with the lash, but good conduct receives its reward and the '' trusties '' have a freedom that is so great as to do away with the stings of imprisonment. The men wear an anklet with a chain attached, but it is wrapped out of sight, and their movements are not impeded by it. A guard of white men is picketed about the mill-grounds, and the sharp crack of a Winchester and the ping of a bullet would follow any attempt to break the cordon.

In the earlier days the differences existing between the mills of Michigan and the mills of Georgia were very great, but the progressive machinery builders have made their influence so widely felt that engines, saws, planers, and mills might be exchanged in a night and the workmen fail to notice a difference in the morning. The variations are due to the class of work. The gang-saw, for example, has no foothold in Georgia because it is not adapted to '' bill stuff,'' while every large mill in Michigan depends upon its gang-saw for boards. Timber is getting less plentiful in Michigan ; the five-sixteenths kerf of the circular is wasteful and the slower cutting band-saw with a kerf of three-sixteenths is taking its place. But aside from this, the planning of the mills, the arrangement of engines, saws, and conveyors is in one section the counterpart of that in the other.

THE SCIENCE OF ELECTROMETALLURGY.

By Alfred E. Hunt, S. B.

TO an Englishman, Mr. C. C. Jordan, belongs the honor of first making known, in 1839, a process for producing metallic copies of any surface by the electrodeposition of metals. Professor Jacobi, of St. Petersburg, Russia, followed very soon after with the same idea. Dr. Golding Bird and Mr. Henry Dicks, in 1837, did much valuable pioneer work upon the art of electrotyping. Sir Henry Bessemer writes of his own work in this art, in the years 1831-32, as follows: "The first conception of the idea of coating works of art in metal with a deposited coating of another metal, if not resting solely with me, was practiced successfully three or four years under my direction before it was brought out by Jordan."

The famous physicist, Sir Humphry Davy, "Father of Electrometallurgy," intelligently described in 1810 the work of electrolysis and the success which he obtained by this method of separating sodium and potassium, and perhaps aluminum and other metals, from their chemical combinations. The methods of electrotyping have been greatly improved since their origin, and much of this development has been due to American ingenuity and skill.

In electrotyping or electroplating, the type, metal, or other object to be plated is placed in a solution of a salt of the metal in connection with the negative pole or cathode of an electric-generator forming the anode, the salt is decomposed by the current, and the metallic element is deposited on the negative pole in connection with the suspended object to be coated, forming the cathode. A piece of the metal is usually attached to the anode or positive pole in the solution, and, by being attacked by the acid formed at the anode, is dissolved, re-forming the salt and regenerating or keeping up the strength of the solution or electrolyte.

A reversed mold or hollow cast of the object to be electrotyped is first obtained, and upon this copper or the other coating metal to be used is electrolytically deposited to a required thickness in this negative impression of the object. Graphite is used as a coating or film for the molds, to produce a conducting surface for the electric current and to facilitate the removal of the deposit when completed.

In electroplating with gold or silver, the object is first cleaned by various processes to remove all oil, dirt, oxid, or other films from their surfaces, so that firmly adhering coatings can be secured. A better-adhering coating can be obtained on copper surfaces than on any other, and many processes of plating include a preliminary coating of copper and then a deposition of other metals upon this coating. The double cyanide of silver and potassium in a liquid containing an excess of potassium cyanide is the salt generally used for a silver-plating bath, although many other silver salts are used for the same purpose.

The physical structure of electrodeposited metals is much affected by the density of the current at the cathode,—the weaker the current the more crystalline the deposited metal. If moderately strong, the deposit will be reguline; and if the current be very strong, the metal will separate of course in larger quantities but in a soft powder, usually black in color, and in an extremely fine state of subdivision.

As with silver, the double cyanide solutions have proved best for gold-plating, but many other salts are used to avoid the use of poisonous cyanides. The color and appearance of gold-plating is altered very considerably by the strength of the current used; too strong a current will give a black non-adherent coating, and the stronger the current the deeper the yellow color of the deposited gold.

Nickel-plating has become of importance since the cheapening of pure nickel to the present price (about 45 cents per pound). The double sulphate of nickel and ammonia is the most-commonly-used salt of the metal, although, as in the cases of copper,- gold,- and silver-plating, very many solutions of different salts of the metal have been used, each with its advantages under varying conditions.

The electricdeposition of cobalt, platinum, iridium, cadmium, antimony, and bismuth has been worked out upon a practical scale, and is more or less useful, as the peculiar advantages of coatings of these various metals are desirable for certain purposes. The electrodeposition of iron upon the surface of engraved copper plates has been advantageously used in order that the printer may obtain a greater number of impressions from the same plate, due to the increased hardness of the iron over copper. Both tin and zinc are more satisfactorily and economically deposited on iron by dipping the iron into a bath of the molten metal than by electrolysis, though both tin and zinc can be electrodeposited readily.

The electrodeposition of alloys has been practiced upon a commercial scale in the plating of brass, of bronze, and of German silver. The same general principles are employed in the plating of alloys.

The plating of some of the metals with gold, silver, and nickel has proved a difficult task. In most such cases, the object to be plated is first coated with copper by either immersion or electrodeposition; and then upon the copper surface the finally desired coating is plated. This expedient has been adopted in the plating of aluminum with success, although another method has lately been devised which is superior.

This latter method consists in first dipping the aluminum into a solution of caustic soda or potash, then dipping into hot dilute nitric acid, then into hot water, then into a solution of corrosive sublimate, then again into the caustic alkali solution, and then into hot water, and finally into a solution of the salt of the desired coating metal, where, by electrodeposition, the final deposit is made.

Electrolysis, or the process of decomposing a chemical compound by the passage of an electric current through it, has lately been successfully used as a means of separation of the metals more difficult to decompose and keep isolated. That this art will soon be carried out on a much larger scale the writer is confident.

By employing mercury cathodes some of the most highly oxidizable metals can be separated, such as chromium, manganese, etc., in the form of amalgams, the mercury absorbing the deposited metal and largely protecting it from oxidation. All that remains to be done in the most of such cases is to distill off the mercury at a low temperature in an inert atmosphere to obtain the metals pure. Electrolysis has been already applied successfully upon a large commercial scale to the refining of copper, silver, and gold.

The principle of the refining process consists in the fact that the electric current does not cause the solution of all of the component parts of the crude metal at the same time, but makes a selection. By taking advantage of this a separation of complex substances is often possible.

In the electrolytic refining of copper, a nearly saturated solution of sulphate of copper is used as an electrolyte. Many tanks are used, placed in series by electrical connections. In this way each tank takes the entire intensity of the current. The impure copper to be refined, as it comes from the smelting-furnaces, is cast into slabs or plates, which are used as anodes, pure thin sheets of copper being used as cathodes. The refining operation goes on until the sulphate-of-copper solution becomes so highly charged with sulphate of iron and other impurities as to necessarily stop carrying on the operation. The residue from the refining operation settles in the bottom of the vats in the form of "mud," and often contains the precious metals in quantities sufficient for smelting.

The rate of deposition of copper is usually from five to ten ounces per twenty-four hours per square foot of cathode surface exposed. Ten amperes of current per square foot are usually employed, unless the large content of bismuth, antimony, or arsenic requires as lower speed of deposition to insure purity. At the large electrolytic copper plants in America the rate of deposition is from 3¼ to four pounds of copper per electrical horse-power-hour.

In the refining of silver, nitric acid of about 36° B. is the solvent. The process is based upon the selective power of nitric acid by which the silver is dissolved and reprecipitated with less electromotive force than the usually accompanying metals, bismuth, lead, and gold. At the works of the Pennsylvania Lead Company a current of 180 amperes is used, with an electromotive force of 1⅓ volts for each pot or compartment, of which there are seventy connected in series in each circuit. Each compartment has three anodes of the silver to be refined, 10 × 20 × ½ inches, and four cathodes of about the same area of thin sheets of pure silver. The anodes are hung in bags to catch the valuable impurities which drop from them in their corrosion. About two pounds of nitric acid per compartment is used in the process per twenty-four hours. The amount of silver deposited is about 470 ounces per twenty-four hours per compartment, or 4.2 pounds avoirdupois per hour per electric horse-power, with a plant producing about a ton of silver per day of twenty-four hours.

Gold is similarly refined from a nitric-acid solution by electrolysis, the metal being first dissolved in *aqua regia* and the excess of hydrochloric acid driven off by evaporation. Aluminum, magnesium, sodium, and potassium are the only metals which are now separated from their ores or salts by electrodeposition on a commercially successful scale.

Aluminum belongs to a class of metals whose oxids are not decomposed by intimate contact with hot solid carbon at any temperature short of the highest heat of a regenerative open-hearth furnace or of the electric arc. Alumina is not only not reduced by hot solid carbon or any other cheap reducing-agent, but it is difficult to reduce in a pure condition by any other process for the reason that any conditions which will reduce the metal are sure to reduce any other metals whose salts may be present with those of the aluminum; thus necessitating the expense of practically chemically-pure reagents and aluminum ores. Again, as the metal has such a small specific gravity, it is difficult to separate from the many varying substances whose specific gravity is about the same, and if separated at the top of the bath, it occasions not only loss by oxidation, but short-circuiting of the pot as well. To add to these difficulties, if heated much above its melting-point (1160° F.) aluminum has the mischievous property of occluding gases with which it may come in contact, rendering the metal porous, weak, and unsound in structure.

Metals which are easily deposited, such as silver and copper, are comparatively easy to electrically deposit pure, chiefly because it takes a much higher electromotive force or greater density of current to separate most elements that would be likely to contaminate them; but with such metals as aluminum the case is different, and to obtain the metal free from impurity requires special precautions.

The metal made by the Hall process is exceedingly pure, the only solid impurities being silicon and iron from the ash of the carbon electrodes and impurities in the alumina ores used. The average metal runs over 99 per cent. pure in ordinary commercial work ; only about two-tenths of 1 per cent. of iron, with the remainder of the impurities almost all silicon, and perhaps a small amount of hydrogen occasionally occluded.

The difficulties of separation of the metal by electrolysis included not only those enumerated for the ordinary methods of reduction, but the additional one that, in order to obtain the necessary conductivity, the mass to be electrolyzed had to be fluid, and all the salts of aluminum practicable to use (especially the oxid) are either very infusible, or, as in the case of aqueous or acid solutions, more difficult to decompose than the solvents themselves.

Mr. Hall, in the early part of 1886, devised the expedient of *dissolving* the oxid of aluminum in a molten bath of the fluoride of aluminum and the fluoride of a metal more electropositive than aluminum, and passing an electric current through the molten mass. For the reason that not only is the oxid the cheapest pure salt of aluminum to produce in large quantities, but it has the added advantage that its product of decomposition (oxygen) is the most easily taken care of. Carbon anodes are generally used in the process, and the oxygen, uniting with the carbon, forms carbonic-acid gas, which evolves around the surface of the anodes, and is, in fact, the only by-product of the process. The continuity of the process is maintained by fresh additions of alumina to the bath, and the dipping out from the bottom of the pots at stated intervals the metal produced and the replacement of the worn-out anodes.

As the electrolysis of the alumina is complete and no waste by slags or volatilization occurs, the operation of reduction of the metal goes on without loss. There are few solvents of alumina which answer satisfactorily the conditions of retaining at least 25 per cent. of their weight in a molten solution of not over about 1800° F., and whose difficulty of decomposition are greater than the dissolved alumina at the temperature necessary for the work, and whose specific gravity will at this temperature be less than that of the molten aluminum produced, so that the metal will go to the bottom of the bath and be protected, rather than come to the surface and both by oxidation and short-circuiting prevent successful operations. Added to these requirements, the solvent must be reasonably cheap and easily procurable in large quantities and not itself corrode the nascent aluminum produced. It must also leave no solid by-product to contaminate the bath and thereby prevent continuity of action. The solvent with its contained alumina must, in addition, be a comparatively good conductor of electricity at the temperature required.

Aluminum chlorid was suggested by Deville as a salt to be electrolyzed for the production of aluminum ; but experiments have since demonstrated that this salt, highly heated or in a molten condition, is a very poor conductor of electricity.

Aluminum fluoride by itself is altogether too infusible a salt to answer the purpose. It is believed that all of the substances that will answer the varied requirements of a successful process as a solvent for alumina are the double salts embraced in the wording of Hall's [United States] patent No. 400,766 : "The fluoride of aluminum, together with the fluoride of a metal more electropositive than aluminum."

The double fluorides of aluminum and sodium, like most electrolytes and gases, as well as mercury and carbon, increase in conductivity with a rise of temperature. The molten solutions used are much better conductors of electricity when charged with from 25 to 30 per cent. of alumina in solution, so that all that is necessary to denote when fresh charges of alumina need to be added is to connect each of the pots with some form of volt-meter and to add fresh alumina to the bath when the voltage increases. The addition of fresh alumina instantly reduces the voltage again to the normal one.

In the comparison of the relative costs of reduction of aluminum by electrolysis and by any chemical smelting process that it would be possible to devise, it can be granted that at least about 78 per cent. of the theoretical maximum electrolytic effect of the current is utilized. It can be further reckoned that an electric horse-power, taken in any considerable quantity per annum, will cost at Niagara Falls at least as low as $30 per annum. At the rate of the deposition of the metal given above, at least 538 pounds of aluminum can be reduced per electric horse-power per annum, at a cost of not over 5 cents per pound for the power. This rate will undoubtedly be considerably decreased in actual practice. Less than an equivalent weight of carbon anodes is expended to the weight of aluminum produced, and in the regular working of the process the loss of the solvent fluoride salts (material used in the solution of the electrolyte) is very small ; so that the total cost, including anodes, of the materials used in the production of aluminum, is as low by the use of the electrolytic method as will probably be possible by any other process that may be devised.

Many other processes for the electrolysis of aluminum have been devised. Sinclair Devill, in the 1850's, made aluminum by electrolyzing it from molten solutions of the double chlorid and fluoride of aluminum and sodium, and Kleiner followed in his steps. He endeavored to make aluminum on a commercial scale in the same way by electrolyzing it from the mineral cryolite, the double fluoride of aluminum and sodium.

Pierre Herault devised a process of electrolyzing alumina itself, first melting the ore and then electrolyzing it by the aid of the current in an electric furnace, having a single large vertical carbon anode. It was found impossible, however, to keep the metal in this way from oxidizing without alloying it with one of the heavier metals, as iron or copper. In ordinary practice, not over 10 per cent. or, at most, 20 per cent. of aluminum alloys were produced, which were irregular in composition and expensive on account of the large amount of current required.

Similarly, and at about the same time (1885-88) the Cowles Electric Smelting and Aluminum Company manufactured aluminum alloys with not over 20 per cent. aluminum alloyed with iron or copper, in horizontal electrical furnaces, mixing the aluminum ore with solid carbon and placing it in the pathway of electric currents of large quantity passing between two sets of carbon poles. The carbon at the high temperature of the electric arc reduces the oxid to the metallic state, but at the high temperature necessary to effect the reduction, as in the Herault alloy process, aluminum can not be produced in the metallic state pure by this method, but only in an irregular alloy of 10, or, at most, 20 per cent. of aluminum with copper or iron.

Grabau, a German metallurgical chemist who devised a very meritorious modification of the chemical process of manufacture of of aluminum by the aid of sodium as a reducing agent, has also invented a process of electrolysis of sodium from molten common salt (chlorid of sodium). By this process, the chlorin evolved was collected and utilized in the manufacture of bleaching-powder in this way making the cost of production of metallic sodium very cheap indeed.

The Aluminum and Magnesium Fabrik Company, of Hemelingen, near Bremen, have so far been among the largest manufacturers of magnesium, sodium, and potassium, and at one time made some aluminum by their process, using compound salts containing aluminum chlorid in their electrolyte. The process was not a commercial success for aluminum, and embodied the usual difficulties connected with the corrosion of the anodes and apparatus.

The manufacture of magnesium by economical methods of electrolysis will quite surely be brought out soon, for the uses for cheap magnesium with a specific gravity of only 1.75, against 2.56 for aluminum, will be large. In other words, "the state of the arts" demands, and the facilities are ready, and the answering cheap production is almost sure to follow in the near future.

Carborundum, the carbide of silicon, is made in an electric furnace by heating for several hours in the path of an electric arc a mixture of 100 parts of sand, 25 parts salt and 25 parts coke. The crystals of carborundum are of a greenish color and have an extraordinary brilliancy. They are also of extreme hardness, which makes the material a very efficient and powerful abrasion agent. Carborundum is the invention of Mr. Edward G. Acheson, of Monongahela City, Pa., and illustrates the further use of the electric current as a powerful agent in the production of chemical reactions.

As a convenient and easily-effected means of separation in quantitative chemical analyses, electrolysis is being used with almost all the metals. And as the methods become better known, they are being more widely adopted. An interesting new use of electrometallurgy is the deposition of metallic salts by the means of electrolysis in the human tissues for therapeutical purposes.

A singular and unfortunate illustration of metallurgical electrolysis has lately demanded public attention in the corrosion of undergound pipes and other metal work by the action of electric currents seeking return conductors to the dynamos of electric railways. When the precautions of a complete and adequate metallic circuit are not taken, the currents seeking the lines of least resistance often take to the water-pipes, and where the surrounding earth is moist, it becomes a sort of electrolyte,—the location where the current jumps to the pipes becoming one of the poles or electrodes, and where it leaves the pipe the other. The moisture of the surrounding earth often charged with acid salts is decomposed ; the haloid element, going to the negative pole, naturally occasions a serious corrosion by its action on the metal work, and the cutting out of the material at the positive electrode as well adds to the serious consequences occasioned.

Special developments have lately been successfully made in partial electrolysis of sea-water (giving to it the antiseptic qualities of chlorid of lime), and the use of this liquid in the purification of sewage and other kindred purposes.

Undoubtedly many uses will be made of the powerful oxidizing and reducing agents which can readily be produced, not only by electrolysis but at the poles of electrolytic cells where they may be conducted away or otherwise used as oxidizing or reducing agents. The chief difficulty to be overcome in most cases is to find anodes capable of withstanding the corrosive action to which they are subjected.

THE ELECTRIC TRANSMISSION OF POWER.

By Francis B. Crocker.

SECOND only in importance to the production of energy is the transmission and distribution of power to the various points at which it is applied. Indeed, it may be said that, at the present time, more interest and greater progress exist in connection with the latter branch of engineering. The actual generation of power is practically limited to two methods: (1) the development of mechanical power from the energy contained in fuel by means of steam- or gas-engines and (2) the production of power by means of water-wheels. The latter method is already sufficiently perfected, the turbine-wheel being very efficient, compact, simple, durable, and cheap, leaving little to be desired. The steam-engine and gas-engine are being gradually and surely improved, especially in their efficiency, but there seems to be no probability of a radical advance, and they do not afford very much ground either for discussion or for visions of great possibilities.

The transmission of power, on the other hand, while apparently less fundamental, nevertheless presents a great many extremely interesting problems and has the potentiality of revolutionizing several of the most important methods of modern civilization. The electric transmission of power from Niagara Falls constitutes in itself one of the most remarkable events of this century. The location of large electrical generating-plants directly in the coal-regions from which power will be transmitted to various cities and towns is another great possibility that is not at all remote. Either of these systems could convey energy to distances of fifty or a hundred miles, or more, and supply the power required, not only for manufacturing purposes, but also for ordinary household uses, including lighting, heating, and power as a substitute for manual labor in domestic work. The widespread distribution of power in a cheap and convenient form, for small as well as large users, would tend to have the effect of preventing the concentration of population in manufacturing towns and might become a considerable element in solving the social and moral problems of factory life. In short, the application and the extension of the use of electric power are almost unlimited, and its development will go on with rapid strides during the next few years. The progress made in the last ten years is a mere beginning, compared with what will be accomplished in the future.

Electric-power transmission, like most of the other great branches of engineering, had a very small origin. Barlow's wheel, invented in

1823, and Faraday's disk, brought out in 1831, were the first forms of motor and dynamo, respectively, and the power of both of these machines was almost infinitesimal. Nevertheless, the principles which they contained have been developed until we now have machines of 20,000 horse-power each. The progress in the use of electric power was greatly retarded by the fact that the only available source of current, until within ten or fifteen years, was the primary battery. This source of current is not only inconvenient and bulky, but is also very expensive, the cost of a given amount of electrical energy from it being ten or twenty times as great as that obtained from a dynamo. The rapid and extensive introduction of the latter machine, and the laying of circuits for distributing the current, have had the effect of encouraging a great development of electric power during the past few years. The first experiment in the long-distance transmission of power is that made by Deprez, between Miesbach and Munich, in 1882. The amount of power then transmitted was small, being only one-fourth of 1 horse-power, and even the electrical efficiency obtained was but 38.9 per cent. A much better result was attained by Deprez in 1885, when he transmitted 40 horse-power from Creil to Paris, a distance of thirty-four miles, the commercial efficiency being 53.4 per cent. and the electromotive force being 5717 volts. Unfortunately, one of the machines broke down for the simple reason that the art of insulating the wires had not at that time reached a sufficient state of perfection to permit machines of such high voltage to be made successfully. The general plan of this system, however, was correct, and a precisely similar plant could be put up to-day that would be thoroughly practicable, provided the insulation and other details of construction were made according to the modern perfected methods. A little later other plants were installed to transmit electric power in Switzerland and in this country, but the distances were not very great, being only ten or fifteen miles.

In 1891, a plant was designed and constructed to transmit energy from the water-power at Lauffen to the Electrical Exposition then being held in Frankfort, Germany,—a distance of 109 miles. This experiment was of extraordinary interest, not only on account of the great distance, but because it also involved the use of the new three-phase alternating current, which is probably the greatest addition to electrical engineering in recent times. The amount of power transmitted (about 100 horse-power) was not quite as great as was expected, but it was sufficient to make the experiment thoroughly practical, and the efficiency obtained, which was about 75 per cent., demonstrated the economy of the method. During the last two or three years many plants have been put in for transmitting electric power over distances of fifteen or twenty miles, or more. These have been so successful that almost every water-power within a reasonable distance of any large city or town is already or soon will be utilized in this way. Many of these water-powers would otherwise be entirely unavailable and worthless. An enormous plant is now being installed at Niagara, by means of which 200,000 horse-power of electric current will be generated and transmitted to various points, not only near the Falls, but also to Buffalo and other places. Since the power of Niagara is estimated to be 20,000,000 horse-power, which is many times greater than the entire power now used by man, it is evident that the utilization of this power is limited only by the distances to which it can be carried and by the number of persons and machines that may be located within that range. Other water-powers not so great, but nevertheless sufficiently large for local use, are available all over the world. The distribution of power from coal-regions, which has already been referred to, may also become of very great importance in the future. By this system not only would the expense of handing and transportation be saved,—and this constitutes the principal part of the cost of coal,—but also the smoke, dirt, and trouble incidental to the use of coal would be entirely avoided.

A system for the electric transmission of power comprises the generating-plant, the line, and the receiving-plant.

The generating-plant consists of one or more dynamos driven by steam- or gas-engines, and the various switches, instruments, etc., required to control and measure the current produced. The line consists of metallic conductors, usually copper wires, which connect and convey the current from the generating- to the receiving-plant. The line should be well insulated to prevent the leakage of current from it.

The receiving-plant consists of one or more electric motors which are driven by the current transmitted over the line, and they produce mechanical power which can be used for any desired purpose. These motors can all be located at one station or they may be distributed at various points where power is required.

The cost of the line becomes a very large item if its length is great; in fact, this is the principal limitation to the distance to which power can be transmitted. The size of the wire required, and consequently the cost of the line, can be reduced by the use of higher electrical pressures,—*i. e.*, currents having an electromotive force of several thousand volts. This is analogous to the fact that a given quantity of water or steam can be carried to a greater distance and through smaller pipes if the pressure be high.

Electrical power is measured in watts, which are the product of the volts and the amperes; hence we can obtain 746 watts, which is equal to 1 horse-power, either by having 74.6 volts and 10 amperes, or 746 volts and 1 ampere. In the latter case the current has only one-tenth the value and, since the size—*i. e.*, cross-section—of wire required is directly proportional to the current, it follows that the weight of wire is only one-tenth as great, with ten times the electrical pressure. This merely takes account of the actual current capacity of the line, but if we consider the *percentage* of loss on the line, the advantage of high pressure becomes still greater. The reason for this is evident from the law that the loss of energy in a conductor is proportional to the square of the current and to the resistance; in fact, it is commonly called the C^2 R loss. Hence, the loss of energy in a given wire is 100 times greater with 10 amperes than with 1 ampere, and the wire must therefore have 100 times the cross-section and weight in order to have the same loss.

This enormous economy in copper, secured by the use of high electrical pressure, practically forces us to employ the highest allowable voltage, whatever may be the particular system or kind of current employed. Currents of 15,000 or 20,000 volts have already been used, and 50,000 volts are now recommended by electrical engineering authorities.

The problem of long-distance power-transmission has practically resolved itself into the question of constructing generators, lines, motors, etc., capable of operating with these extremely high voltages without injury to the apparatus itself or to persons and property.

Four different systems are available for the purpose, according to the character of current employed: (1) direct current; (2) simple alternating current ("single phase"); (3) two-phase alternating cur rents; and (4) three-phase alternating currents.

Any one of these four systems might be employed for either short or long distances, and combinations of two or more of them might be adopted advantageously in certain cases. The difference between these various kinds of current and the relative advantages and disadvantages of each is a much discussed matter at the present time. The probability is that there is no general solution of this problem, and that each particular case would have to be decided on its merits. In the most common cases of power-transmission the distance varies from ten to thirty miles, and any of these four methods could be used so that it is often difficult to decide which is the best. The proper way to consider the matter is to study each system and carefully weigh its advantages and disadvantages.

The direct-current system could employ a single dynamo to generate the current, but for long distances it would be better to connect two or more machines in series, and this applies also to the motors. In this way the total electrical pressure would be subdivided and the voltage that would have to be carried by each commutator would only be a fraction of the whole amount. Very high electrical pressures might cause a commutator to flash badly. Hence the necessity for having a commutator is the chief objection to the direct-current system, but since machines of 5000 volts are in regular and successful use for arc-lighting, it would be possible to obtain 20,000 volts from four of such machines in series. The subdivision of the pressure would also reduce the danger of breaking down the insulation of the machines.

Another disadvantage of the direct-current system is the fact that it requires a dynamotor to transform it from a higher to a lower pressure, or vice versa. This machine is a combination of a motor and a dynamo, and is more expensive and likely to get out of order than the simple stationary induction coil which is used to transform the alternating current.

The direct current has the advantage over the alternating-current system in the fact that it is entirely free from any loss or disturbance due to the static capacity and self induction of the line. These two matters are somewhat technical, but they play an important part in all electrical circuits, in which alternating or variable currents are used. The effect of self induction is to cause a very considerable fall in electrical pressure and the effect of static capacity is to absorb and give out, as it were, a considerable quantity of electricity each time the line is charged and discharged by action of the alternating current, which in ordinary practice reverses its direction of flow 50 to 250 times per second.

The direct current experiences no loss whatever from self induction or capacity, the pressure lost being merely that required to overcome the resistance of the line expressed in ohms, which loss also occurs with the various forms of alternating current in addition to the peculiar actions referred to. Besides the separate effects produced by static capacity and self induction, it is also found, when these two factors bear a certain relation to each other, that the peculiar phenomenon of electrical resonance occurs, putting the line into an extremely sensitive condition and causing abnormal rise of electrical pressure at certain points. This might act as a disturbing element and even break down the insulation of the machines, transformers, or line. On the other hand, it is often attempted to neutralize the bad effect of either static capacity or self induction by balancing one against the other. But this matter is still very new, having become part of electrical engineering only during the past year, and at present it exists as a rather doubtful question in alternating-current work.

The simple alternating-current system as used for electric-lighting can be adapted to power-transmission. For example, it is possible to take two alternating-current dynamos of the ordinary form and use one as a generator and the other as a motor. The difficulty, however, is that the motor must be started and brought up to exact *synchronism* in speed with the generator by some other power before it will run by itself and then, if for any reason it happens to be thrown out of perfect agreement in speed, it will stop entirely. The objection to having some auxiliary power to start the motors and the liability of the latter's being stopped by any load being suddenly put upon them makes this system somewhat unpopular for general use at the present time, particularly if there were a large number of motors. Self-starting motors for the simple (" single phase ") alternating current have been devised, but up to the present they are not found in extensive use. There is a great demand for a thoroughly practical motor of this kind and it is to be hoped that they will soon be available in all sizes.

The advantages of this system are its simplicity and the ability to convert from any given voltage to any other by means of a very simple transformer, consisting of a core of iron upon which there are two coils of wire, all the parts being stationary. The simplicity of the alternating-current transformer is really the great advantage of the single-phase as well as the two- and three-phase systems. For example, the dynamo may be constructed to generate a harmless current of say 200 volts, and by means of a " step-up " transformer it is changed to say 25,000 volts, which is suitable to long-distance power-transmission. At the receiving end of the line the current can again be changed by " step-down " transformers to 200 or any other number of volts for use in the motors.

If desired, the 25,000-volt current can be first transformed to 1000 volts to make it suitable for distributing through the streets of a city, and again transformed at each house to 100 volts to be used for supplying incandescent lamps or motors. The efficiency of a transformer is so remarkably high, being 96 or 97 per cent., that several transformers can be made with a total loss of only 5 or 10 per cent.

The two-phase alternating current really consists of two simple alternating currents of the ordinary kind which differ in phase ; that is, when one current has its maximum strength the other is just reversing and vice versa.

These two currents may be carried on entirely distinct circuits by separate wires having no electrical connection with each other, or, for the sake of economy, the return wires of the two circuits may be combined as one wire, making three conductors in all. The two-phase current, when applied to a magnet made in the form of a ring, tends to produce a continuous rotation of the polarity, so that a bar of iron pivoted at its center and placed within the ring magnet will revolve with the polarity being drawn around by it. This takes by the magnetic attraction through the air without any magnetic or electrical contact with the revolving bar. This very beautiful and at the same time practical method of producing rotation is substantially the principle of the two-phase motor. In practice the revolving armature is not a mere bar of iron, but it is of simple construction and requires no electrical connection to be made to it and this fact constitutes the essential advantage of the two-phase motor. Its disadvantages are the fact that three or four wires are required for the circuit instead of two, and for electric-lighting the two circuits are apt to affect one another and cause variations in the lamps. These are in addition to the general troubles which occur with alternating currents, as already stated.

The three-phase alternating current consists of three currents differing in phase. In this case the three circuits act mutually in such a perfect manner that three wires are sufficient, and each wire serves successively as the return for the other two. The general principle of this system is similar to that of the two-phase, and it is also specifically applicable to power-transmission.

The single-phase, the two-phase, and the three-phase alternating-current motors may be likened to the single, double, and triple cylinder steam-engines. In the single-cylinder engine the steam-pressure is applied back and forth in the same line and the engine is liable to be caught on the dead-center, in which case it is not self-starting; in fact, a fly-wheel is required to carry it over the dead-center in order to produce continuous rotation even after it is started. In an analogous manner the single-phase motor is not ordinarily self-starting and requires some device to carry it over the dead-center. A two-cylinder engine, such as the locomotive, for example, having the cranks at right angles to each other, is always self-starting for the reason that when one is on the dead-center the other is in its most effective position. The two-phase current acts similarly by forces applied at right angles to each other, producing a continuous rotary effect.

The three-phase current, like the three-cylinder engine, secures, by the combination of three forces acting at angles of 120° to each other, a still more uniform and perfect effect.

In conclusion, it may be remarked that the whole subject of electric power-transmission is still an undecided one. The two- and three-phase systems, which may be considered together under the title of polyphase, since they are not materially different, are now claimed to be preferable to either the direct-current or single-phase systems, but some engineers advocate the latter two methods, and in many cases they would certainly be more desirable. The probability is that in this, as in many other branches of engineering, each system or form of apparatus has its proper application and sphere of usefulness, and that there is no *universal* system or type of machine for all uses.

THE PRESENT AND FUTURE LOCOMOTIVE.

By David L. Barnes, M. Am. Soc. C. E.

THE demand for quick transit for both passenger and freight trains and the need for all possible reduction of operating expenses make the development of the locomotive an interesting subject, especially in the matter of the limitation to the increase of size. There is a point beyond which the locomotive cannot be increased in weight and power without passing the most economical plan of operating a railroad. In slow freight service the limit is found when a further increase of train-load so increases the cost of fuel and loss due to delayed freight that there is a greater total cost of transportation per useful ton-mile,—" useful ton-mile" being one ton of paid freight hauled one mile. The chief advantage of heavy freight-trains is found in the decreased cost of wages and locomotive expenses, outside of fuel, per useful ton-mile. Two disadvantages are the decreased efficiency of the boilers when forced to a greater degree and the more frequent delays to freight caused by the heavy loads, *per se*, and by the parting of couplers between cars under the heavier strains. On level roads, with strong car-couplers, Westinghouse brakes, and large locomotive-boilers, the maximum economical train-weight is high, while on uneven roads, with ordinary link-couplers and with boilers having small grates, the maximum is comparatively low.

Where fuel is high in price, as in Mexico (about $18 a ton), and wages are low, the maximum economical train-weight has been reached for the present; a further increase must wait for a cheaper fuel. The steam-cylinders and boilers of locomotives are generally worked above the most economical point, and an increase of load reduces the efficiency. Hence, where fuel is excessively high, it is generally the case that additional loads cost more in fuel than is saved in other ways.

In passenger service the limit of train-weight is always found in the speed; each increase of speed demands an additional amount of steam per minute and, consequently, there is an increased demand on the boiler. This would be true even if the train resistance did not increase with the speed, for the reason that with the same resistance the distance traveled over is greater at the higher speed in the same time; therefore more work is done and more steam must be used per minute. In fast freight service the limit ot train-weight is found in speed, just as in the passenger service.

With locomotives the weight of fuel used per square foot of grate an hour, or what is called the " rate of fuel use," is enormous when compared to stationary-boiler practice, and the blast is so fierce that much of the fuel is drawn through the tubes and passes to the stack unburned and wasted. The approximate diagram Figure 1 indicates several important conclusions, viz. :

The weight of fuel used per square foot of grate an hour in locomotive-boilers in railroad practice in the United States is fully eight times that used in stationary boilers, and three times that used in locomotives in England and on the continent of Europe. On heavy grades the rate of fuel used is much higher than on level track, and each increase in the rate causes a decrease in the efficiency of the boiler. The words "fuel used" are here employed instead of the more common expression "fuel burned," for the reason that much of the coal shoveled into locomotive fire-boxes is not burned, but goes unburned through the smoke-stack in the form of cinders. From the diagram Figure 1 it is clear that the best practical economy is obtained only by using fuel at a rate at which it can be well burned; it is also seen that there is a limit to the train-weight that can be hauled with reasonable economy in the use of fuel.

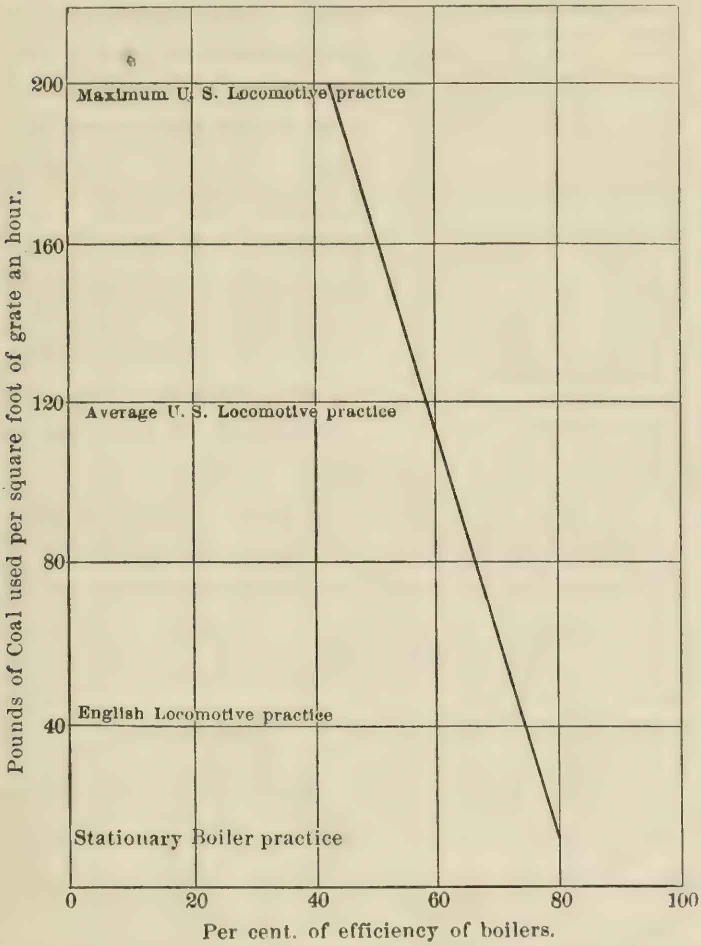


FIG. 1—DIAGRAM SHOWING REDUCTION OF EFFICIENCY DUE TO FORCING LOCOMOTIVE BOLIERS.

The diagram Figure 2 shows approximately how the fuel required per ton-mile changes when the same locomotive is used and the load is increased or reduced. The diagram Figure 3 shows how the maximum attainable steam-power, with reasonable efficiency, decreases as the speed increases on the same locomotive when the parts are well designed and the valve-motion is of the Stephenson link type. The decrease in power results from two things: the friction of the steam in passing through the passages and the decrease in the amount of steam admitted to the cylinders at each stroke.

One might ask, why not admit more steam? The reply is, that the largest amount of steam that can be admitted without "choking up" the engine to an uneconomical point is generally admitted now, and also that, if the engine is run with a long cut-off and the power is regulated by the throttle, this being the method by which the most power can be obtained at high speeds, the efficiency is greatly reduced and the boiler is more severely taxed.

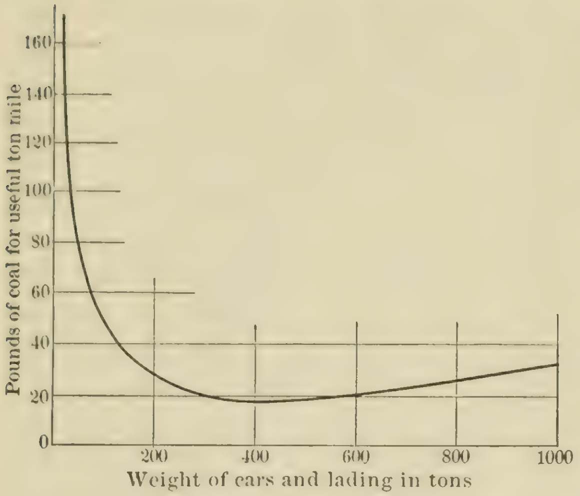


FIG. 2.—DIAGRAM SHOWING APPROXIMATELY THE FUEL REQUIRED PER TON-MILE WITH DIFFERENT TRAIN-LOADS.

Where the efficiency of the locomotive is a secondary consideration and the speed is the most important factor, then the limit of speed is found in the steaming capacity of the boiler, and it must be found by actual trial in each case whether, with a given locomotive, more power for hauling trains can be obtained for long runs by disregarding the efficiency and using the steam in the cylinders with a long cut-off and regulating with the throttle, or by using a short cut-off and regulating with the reverse lever. For a short time the boiler can be drawn upon for an unusual supply, but for a long run the maximum power of a locomotive will probably always be had when the steam is used in the cylinders with the highest efficiency, and experience has practically proved that the maxium limit of load for a long run is reached when the steaming capacity of the

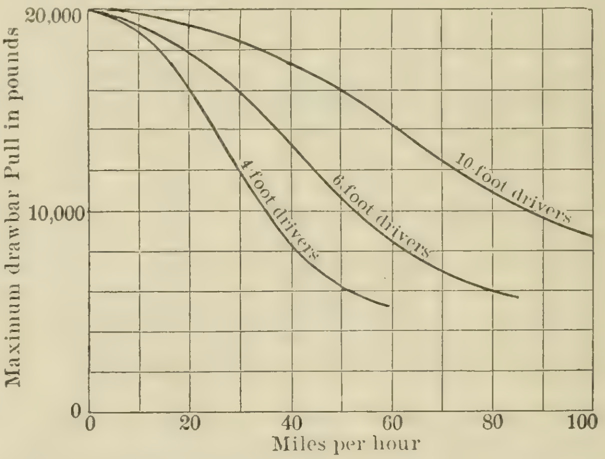


FIG. 3.—DIAGRAM SHOWING DECREASE OF MAXIMUM ATTAINABLE STEAM-POWER AS THE SPEED IS INCREASED.

boiler and the efficiency of the cylinders are nearly at a maximum.

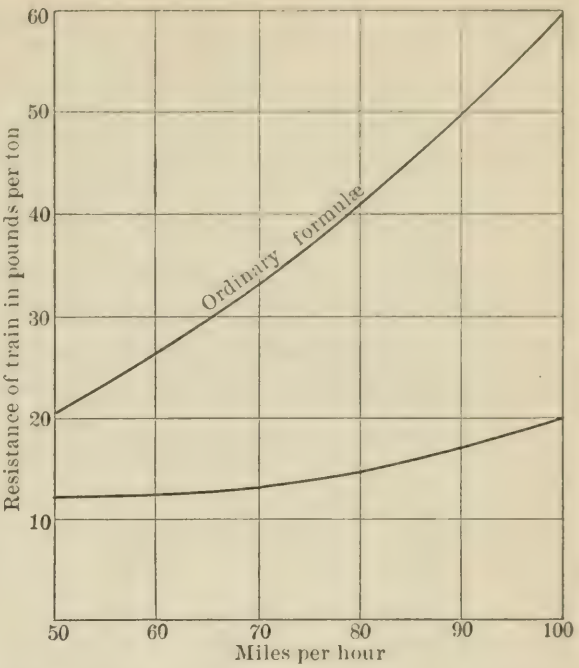


FIG. 4.—DIAGRAM SHOWING ERRORS IN ORDINARY FORMULÆ FOR TRAIN RESISTANCE AT HIGH SPEEDS.

The diagram Figure 4 shows approximately the variation of train resistance for different uniform speeds. When the speed is changing the resistance is quite different from that shown on the diagram, as it is materially affected by the inertia of the train. When the speed is increasing the inertia increases the resistance and when the speed is decreasing the resistance is decreased. Figure 5 shows approximately how the inertia affects the resistance in starting out from a station and accelerating a light passenger-train on a level track to eighty miles an hour. These diagrams are based on the few tests that have been made up to ninety miles an hour, and are based on the assumption that the bearings have been warmed by running. If the train has been standing a long time at a station before starting, the resistance from the

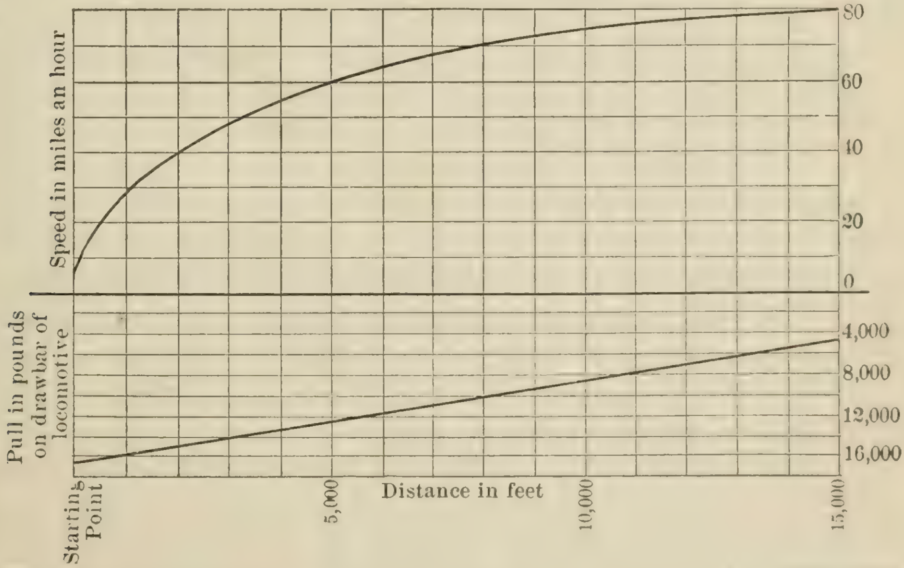


FIG. 5.—DIAGRAM SHOWING THE EFFECT OF INERTIA ON THE TRAIN RESISTANCE WHEN THE VELOCITY IS INCREASING.

starting-point to a speed of thirty miles an hour is greatly increased. The air-resistance is not so great as has been understood from the formulæ that are given in technical books. If these formulæ were correct, railroad trains could not be hauled at one hundred miles an hour by our present equipment. Take, for instance, the Empire State Express train, of 283 tons. The formula for resistance often given is $\frac{V^2}{171} + 8$. This would give a resistance of 66.5 pounds per ton on a level, or, for the whole train, 18,800 pounds. This would require at least 5000 horse-power to be generated by the engine, and is, of course, impossible. Probably 1200 or 1400 horse-power is the maximum capacity of the Empire State Express locomotive, and the resistance is more nearly what is shown by the diagram, Figure 4. Figure 6 shows the resistances due to grades alone; these are not included in the diagrams Figures 4 and 5.

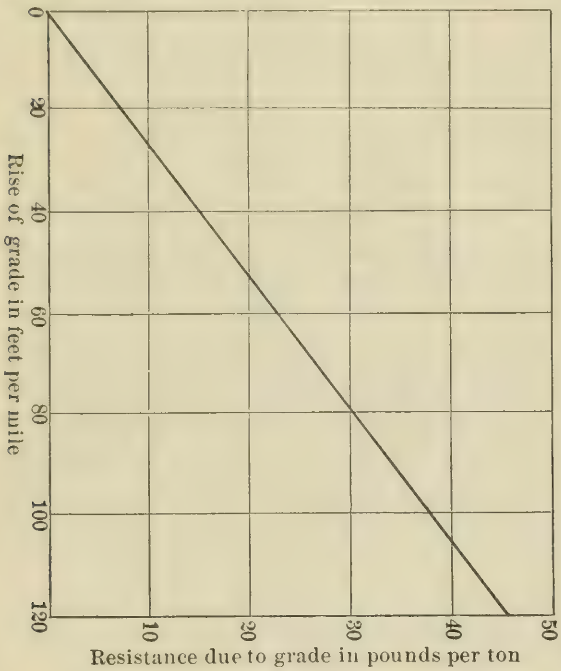


FIG 6.—DIAGRAM SHOWING THE RESISTANCE DUE SOLELY TO GRADES AND NOT INCLUDING THE FRICTION OF AXLES.

The limit of locomotive boiler-power is nearly reached at present, and, unless two separate grates are used, no more fuel can be burned on a locomotive than can now be burned with the largest grates we have in use. A grate ten feet long is about as long as a fireman can care for properly, and when it is as wide as the present Wootten grates it can be no wider without exceeding the maximum allowable width of a locomotive. It is evident that two separate grates, placed one ahead of the other, will be necessary if much more fuel must be used than can be burned at the present time. Two grates would require practically two boilers to give the necessary heating-surface, and would lead to changes and complications that are not permissible so far as can now be seen.

The gain in economy to be derived from the use of two boilers would be very small, and the gain in weight of trains at high speed that would be possible with the double grate would probably not reduce the expenses per passenger-mile enough to pay for the trouble incident to the use of two large boilers on one locomotive. It might be said that such an increase of boiler-power would permit an increase of speed, and so it would, but a speed of one hundred miles an hour is possible now with light trains on straight track, and that is as fast as it will be safe to travel until better protection is given to trains while running, and even then it will not be safe until passenger-cars are made of metal and adapted to resist shocks without breaking into sharp and ragged fragments, which are a menace to life. One wreck or a collision at one hundred miles an hour, even with the best of our wooden equipment, will greatly cool the ardor of high-speed enthusiasts.

In all discussions of high speed it should be remembered that a high maximum speed is not what is wanted, but a high average speed. The saving of time between terminals depends upon the average speed, not upon the maximum. The maximum may be high and yet the average be low. A quick run from New York city to Chicago would be eighteen hours, and this would require an average speed of only fifty-five miles an hour. A maximum speed of one hundred miles an hour is unnecessarily high to give an average of fifty-five miles. The distance from Jersey City to Philadelphia is ninety miles and the run is now made in 1.95 hours, which gives an average speed of forty-six miles an hour. To make the run in 1.5 hours requires an average speed of but sixty miles an hour, so that it is clear that the high speed now asked for by the public is not a high maximum but a high average, and to meet the demand for quick service there must be steady running at a reasonable speed. High maximum speed is spectacular but not practical, while high average speed is a real necessity, and can be obtained ; for such service locomotives need power at starting and a larger boiler-capacity for work on light grades. High average speed on heavy grades is impossible within the limits of steam locomotive construction. A grade of 1 per cent. demands about 1500 additional horse-power at one hundred miles an hour, and 900 additional horse-power at sixty miles an hour, in the case of the Empire State Express train. This shows how a light grade may increase greatly the demand on the locomotive boilers at high speed. Probably the most feasible way of making quick time between terminals is to give the trains a clear track and reduce as much as possible the curves and grades, just as has been done by the Lake Shore and Michigan Southern road within a few years.

The present light freight engine is shown by Figure 7, the heavy freight engine by Figure 8, and the usual mountain type by Figures 9 and 10. These types are varied somewhat by changes in the type of boiler and in the dimensions of the wheel-bases and wheels, and in the location of the trucks, but in the main the illustrations show the best present designs. In the future, steam freight locomotives will probably be made on these lines with no radical changes. The limit of increase of dimensions must be governed by the maximum single grate that can be properly fired. No doubt there will be changes in the boilers and cylinders that will increase the efficiency and, generally speaking, the weight of trains can be increased when the efficiency is increased. The use of compound cylinders and high steam-pressures gives a higher efficiency and permits more useful work to be done by the steam generated with a given boiler-capacity; probably, then, the principal differences between the present steam freight locomotive and that of the next decade will be found in the compound cylinders, the increased steam-pressure, and the small increase of grate-area and heating-surface of the boilers, but the type of locomotive undoubtedly will remain about as it is now.

For suburban work there have been many recent improvements in design. Formerly old locomotives taken from main-line service were used, but now special designs have been introduced and the type shown by Figure 11 may be taken as representing that of the near future, that is, until the electric motor replaces the steam locomotive for this class of work. The simplicity of construction and the high efficiency when the cylinders are made compound give to this type its principal advantage.

In passenger service some decided improvements have been made in the past ten years, and the dimensions of the boilers have in some instances practically reached the limit of extension for a locomotive carried on four drivers. The largest grate-area and boiler-capacity is that given by the Wootten boiler locomotive, Figure 12, which is a new type known as the "Flying Dutchman." A similar type is the "Columbia," shown in Figure 13. This locomotive is a four-cylinder compound. One of the most important and the very latest modification of the present standard type of high speed passenger locomotives is the two-cylinder compound No. 1515 of the Pennsylvania road, Figure 14. For heavy passenger service with moderate speed the ten-wheel freight type, Figure 7, is quite extensively used, but the wheels are generally made about one foot larger in diameter for passenger service.

These are the distinct types of passenger locomotives that are now considered generally useful, and no other type has been offered that appears more desirable or that will give more advantages than these. In the case of the Wootten boiler the grate-area is nearly, if not quite, at the maximum that can be properly fired from one end. The weight per wheel of passenger locomotives is already near the limit that is safe on present track and bridges. The steel bridges now built are practically permanent and the best roadbeds are about as stable as it is economical to make them. Some passenger locomotives have now all the boiler-

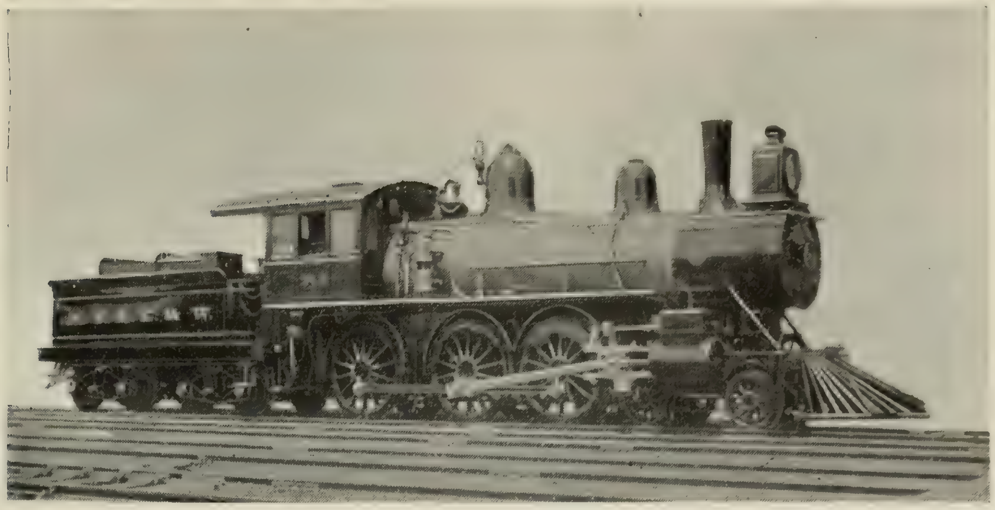


FIG. 7—MODERN TEN-WHEEL FREIGHT AND PASSENGER LOCOMOTIVE.

power that can be given them without passing the limit of weight, and it is probable, therefore, that in the future the steam passenger locomotive will not be changed much, although the weight and power may be increased a little. The demand for quick runs over long distances will not be filled by building locomotives for excessive speeds, but by so arranging the time-tables and decreasing the curves, grades, and number of stops that high uniform speeds can be maintained for considerable periods of time. The erratic designs of locomotives, such as the Fontaine, the single driver without parallel rods, the Polygonal driving-wheel, the Shaw locomotive, and other marked departures from types

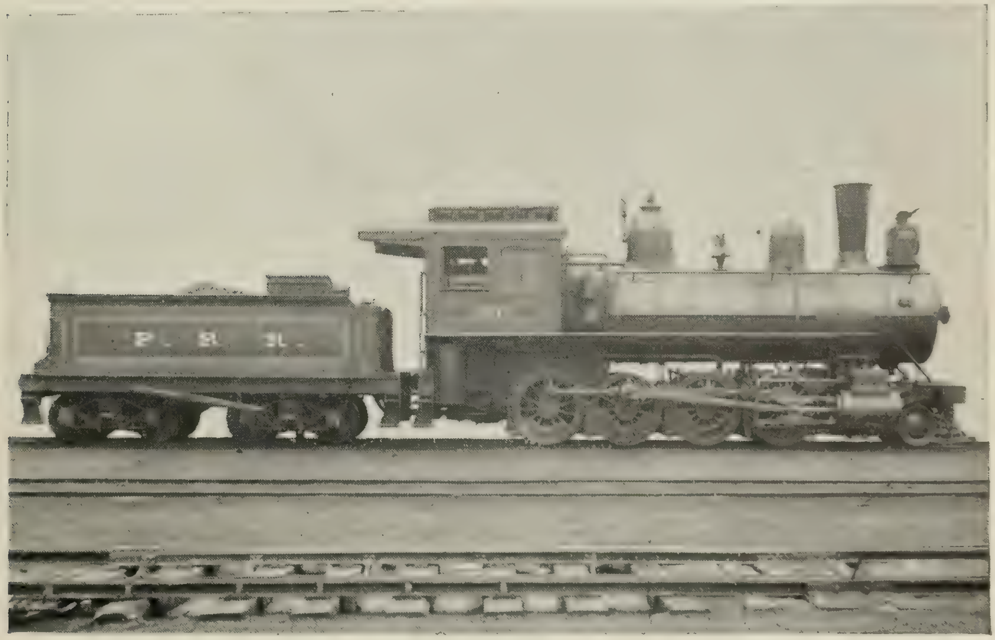


FIG. 8—MODERN HEAVY FREIGHT LOCOMOTIVE, CONSOLIDATION TYPE.

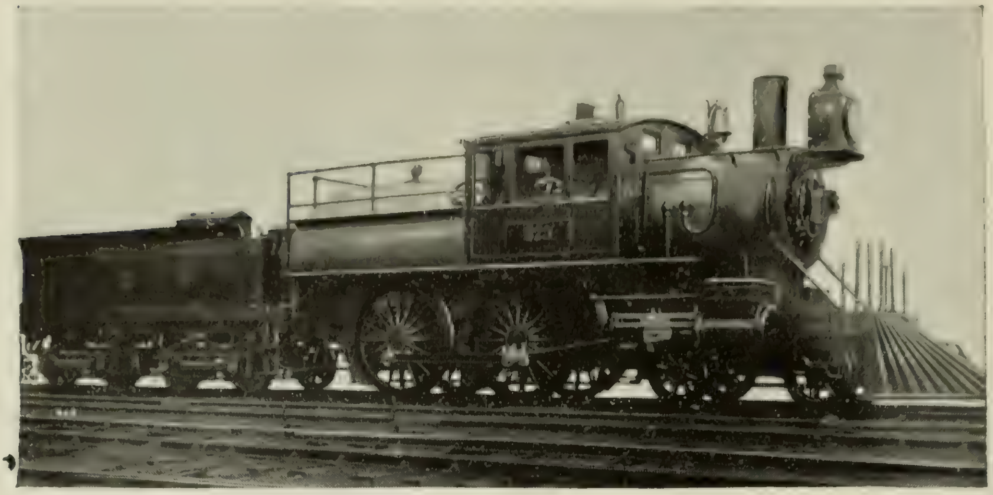


FIG. 9—MOUNTAIN CLIMBER, DACAPOD TYPE.

that have been developed by actual service, have not brought out a single feature that it is desirable to add to the present standard design, and radical changes are not to be expected in the future.

One of the most disputed points has been the use of the parallel rods, and American railroad-men have been criticised by Europeans for using parallel rods for high-speed locomotives, but, after long experience in Europe without the parallel rod, and in this country with it, the rod remains, and its use has been justified by experience. In Europe the newer types of engines have the driving-wheels coupled

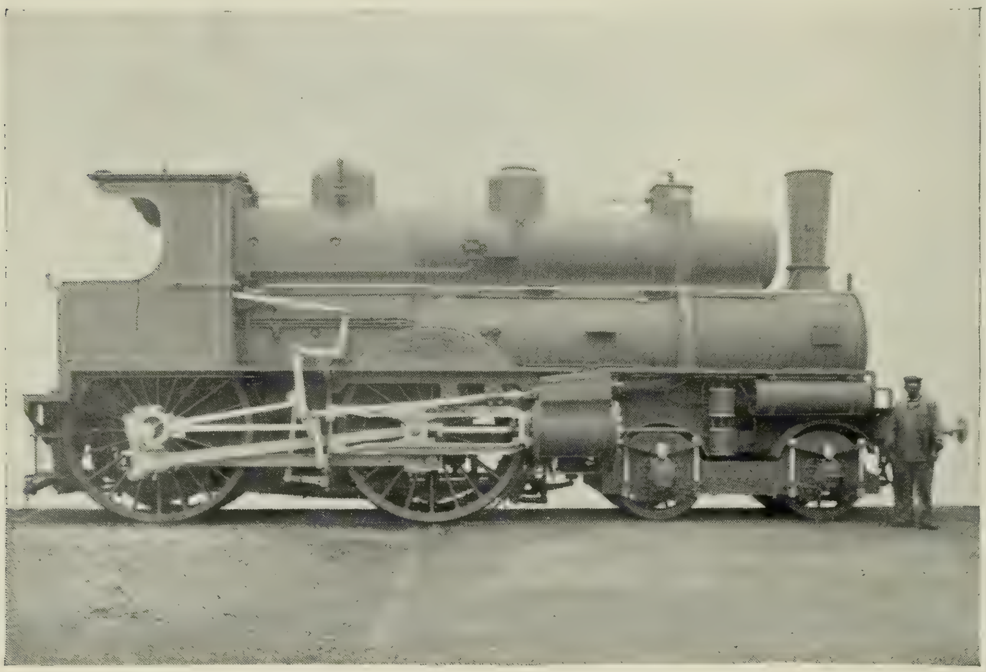


FIG IO.—MOUNTAIN CLIMBER WITH TANK, DACAPOD TYPE.

together by rods to gain the increased adhesion that is needed for making high average speed, which is, as has been here shown, the essential element of the quick average running asked for by the public.

So far only steam locomotives have been considered, but something should be said about the possibility of the electric locomotive. The future locomotive in some cases will certainly be driven, as now, by steam, but where very high maximum speeds are needed and grades are to be traveled over at considerable velocity, and on suburban lines and sections where the traffic is crowded, electricity will be the motive-power. The reasons are clear from what precedes, as the necessary boiler-capacity cannot be given to a locomotive to permit high train velocity on the grades that are now common on main lines. With electricity any reasonable amount of power can be supplied from the central station, where room may be provided for any desired boiler-capacity.

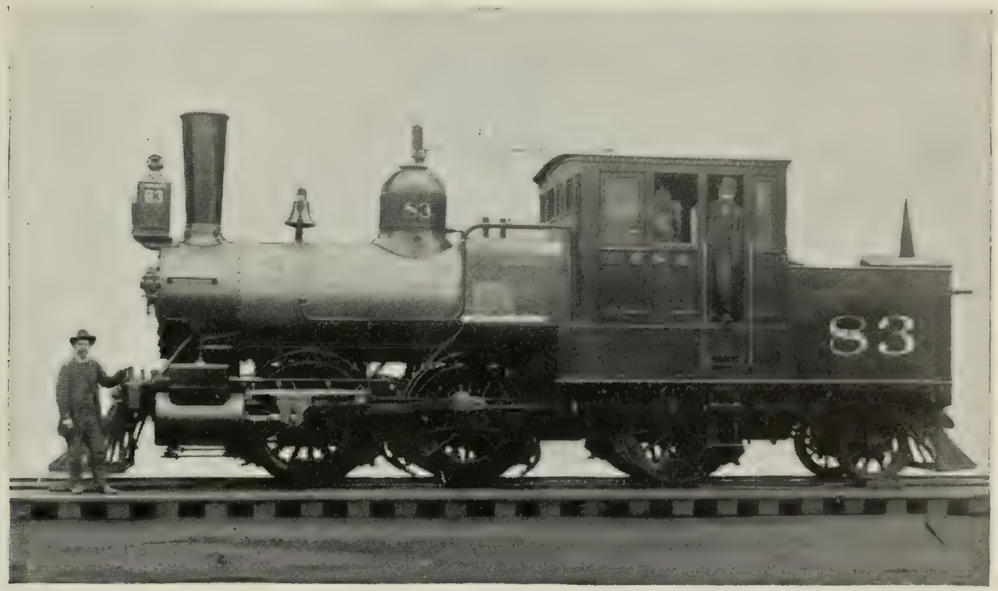


FIG. II —MODERN SUBURBAN LOCOMOTIVE.

It is not at all probable that the immediate future will find electric locomotives taking the place of steam on main lines for regular work, as the expense of installation is out of proportion to the advantages to be gained by the change, but for elevated roads, suburban work, and switching, the change will be rapid after a few actual plants have proved the practical superiority of electric transmission. The present experience with electric motors in England and in this country for quite heavy trains is enough to establish an important conclusion: namely, that the transmission of power from a central station by the electric current, and its transformation into mechanical work at the train by means of electric motors, is a practicable and efficient method of fur-

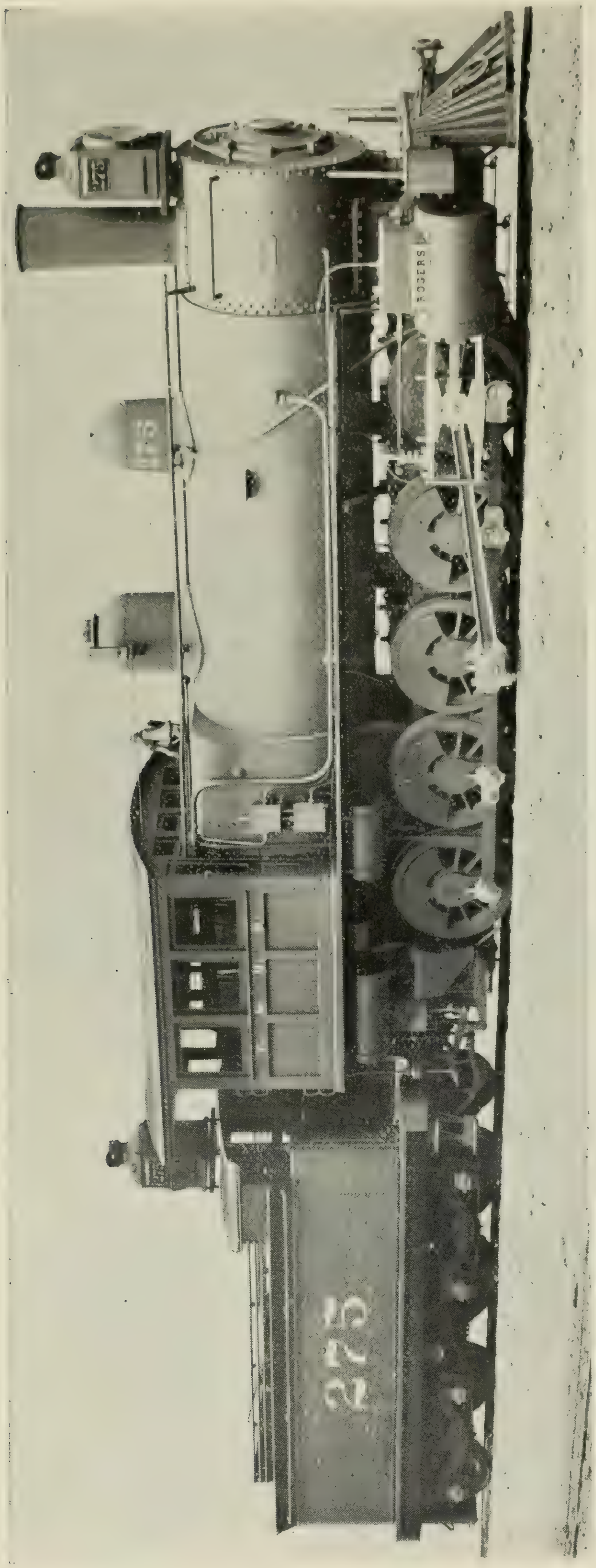


FIG. 12.—HIGH-SPEED PASSENGER LOCOMOTIVE, "FLYING DUTCHMAN" TYPE.

nishing power to locomotives, while the cost of fuel and repairs is less than with the steam locomotive; but the other expenses, that are made up of interest, taxes, ground-rent, etc., are dependent upon a multitude of conditions peculiar to each railroad, and the final relative economies of the two systems must be learned from a study of the conditions existing in each particular case.

To sum up, we are now entering upon an era of change of motive power from steam directly applied, as in our present steam locomotives, to electric transference of power from a central station to moving trains. The change must necessarily go on slowly, commencing first with the suburban, switching, and elevated services, and finally beginning in main-line work where the traffic is crowded. The steam locomotive

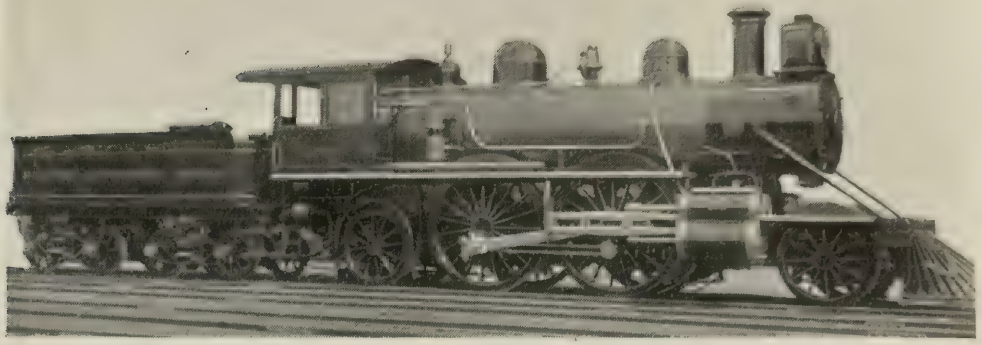


FIG. 13—HIGH-SPEED EXPRESS LOCOMOTIVE, "FLYING DUTCHMAN TYPE," FOUR-CYLINDER COMPOUND.

will not be altered much in appearance or power from the best of the present designs, but improvements will continue in detail so long as it remains in use. We are nearly at the limit of economy with steam locomotives where there are large boilers and compound cylinders, and where the engineer and fireman are competent and the loads not excessive, and the maximum capacity is about as great in some cases as it is practicable to make it; hence, for higher efficiency and greatly increased hauling power at high speed, concentration of power is needed. So far as can now be seen there must be a stationary plant where power can be concentrated, and electricity seems the only practical means of transferring such concentrated power to moving trains.

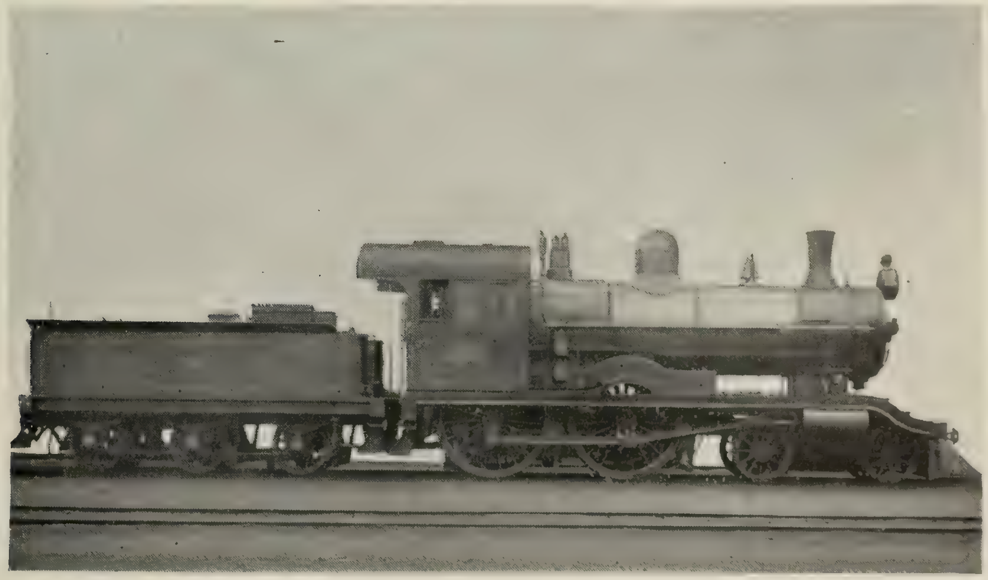


FIG. 14—POWERFUL EXPRESS LOCOMOTIVE, TWO-CYLINDER COMPOUND.

ELECTRICITY

Conducted by Franklin L. Pope.

IT is evident that the time is rapidly approaching when all conductors for electric-light and -power service, at least in large cities, will have to be laid underground. In that event, it will be a matter of great moment that effectual means shall previously have been devised by which incandescent, arc, and motor service, or other kinds of service, may be taken from a single generator and a single pair of conductors. It has already become evident that the key to the solution of this problem is to be looked for in some development of the polyphase system. During the past year, much space has been occupied in the technical papers in the discussion of the respective advantages offered by the two-phase and the three-phase methods of transmission. Perhaps the most striking paper on the subject which has as yet been presented, and certainly one of the most valuable from a practical point of view, is that of Mr. Charles F. Scott, which was read at the annual meeting of the National Electric Light Association, and which should have received earlier notice in this Department. In the management of the larger class of alternating-current stations, some very perplexing phenomena have from time to time presented themselves; phenomena which have served to puzzle some of our most accomplished electricians. It is but simple justice to the author of this paper to say that he has made the occult causes of most of these mysteries so plain that they may be easily comprehended by any ordinarily intelligent electrician. Commencing with some experimental illustrations of the curious effects of self-induction in alternating circuits, which are well illustrated with diagrams really illustrative in their character, Mr. Scott passes to the consideration of the phenomena of fall of potential or "drop," in both direct and alternating circuits, which prepares the way for the discussion of the two vital factors in alternating distribution, loss, and regulation, the Scylla and Charybdis of the electrical engineer. The methods by which the drop of an alternating circuit is computed are next taken up, and a most ingenious chart is given, showing at a glance the inductive electromotive force in volts per ampere per thousand alternations per thousand feet of circuit, at different distances between centers of conductors, which has been warmly praised by Professor Forbes and other prominent electrical engineers, and which cannot but be of the utmost service to the future designers of large plants for the transmission and distribution of electric power. The phenomena of self-induction as affecting the converter, are discussed and the methods of testing these appliances explained. More than one station-manager has been worried nearly to distraction by unaccountable fluctuations in the brilliancy of the incandescent lights at the end of a long circuit, occurring with monotonous regularity and baffling all his efforts to locate the source of the trouble. Mr. Scott shows this effect to be due to the mutual induction set up under certain conditions between two parallel circuits on the same line of poles, producing an action and reaction analogous to that in the primary and secondary circuits of a transformer. But perhaps the most important part of the paper is Mr. Scott's discussion of the relative advantages of the two-phase and the three-phase methods of distribution. The author contends that the three-phase, three-wire method requires 23 per cent. less copper for transmitting a given amount of power under otherwise equivalent conditions, which in many cases is a matter of considerable importance. There are other conditions which tend to increase this advantage, among which may be mentioned the fact that the drop due to self-induction is ordinarily only about one-third as great. On the other hand, the two-phase method is admitted to possess important advantages in operating a lighting service, in which one or another branch of the system is liable to become overloaded. The ease and simplicity of installation are also much in favor of the two phase method. With these facts in mind, Mr. Scott describes a method of his own invention, in which he has attempted, and apparently with success, to combine in one system the advantages of the three-phase method for transmission and of the two-phase method for distribution, which he proposes to effect by a peculiar organization of converters at the center of distribution. The loss of efficiency at the point of conversion from one method to the other, has been experimentally determined to be no more than one-tenth of 1 per cent. It is believed by prominent electricians who have expressed their opinions on the subject that Mr. Scott's paper is destined to mark an important era in the science of electrical power-transmission.

IN the annual report of Mr. Andrew Rosewater, city engineer of Omaha, Neb., the problem of making a great manufacturing center of that city by means of a water-power situated seven miles away receives the consideration which its importance merits. Mr. Rosewater computes that the cost of a net horse-power at the water-wheel shaft will be from $8.08 to $9.60 per annum, according as the plant is laid out for twenty-four or ten hours service per day. The cost of a net horse-power in the city, by electrical transmission, is estimated at from $23.59 to $25.76 per annum. The cost of installation of the hydraulic plant is figured at $67.33 and $80 per horse-power, respectively, and that of the electrical plant, at present prices, at about $73 per horse-power. Mr. Rosewater estimates that an equal amount of power (20,000 horse-power) can be delivered by a compressed-air system of transmission at $19.98 per horse-power. The final conclusion is, that while electrical transmission is preferable for such power as may be needed for strictly electrical purposes, such as street-car service and illumination, compressed air offers many advantages over electricity for general power distribution. It is probable that Mr. Rosewater's figures and conclusions will be vigorously criticised by electrical engineers, but he seems, nevertheless, to have given the whole problem very careful consideration.

THE *Electrical World* points out that the column given in many electric wire-tables, showing the number of feet per ohm of different sizes of conductors, may be made to serve to show also the number of ampere-feet per volt. This will be useful in many computations. For example, in calculating the field-winding of a dynamo, find the ampere turns required and then the ampere-feet. If this be divided by the voltage, the quotient is the ampere feet per volt that the right size of wire will give. The table will then show the nearest size of wire to be used.

A CENTRAL station at Lexington, Ky., operating about 7000 incandescent lights, has for some months been using two recording volt-meters, one being in the station, and the other at one of the principal centers of distribution more than a mile away. The first charts taken showed that the pressure varied anywhere from 49 to 56 volts, but the dynamo-men have apparently become much more careful of late, as the recent cards show a very small variation during the 24 hours. Mr. E. J. Richards, the superintendent of the station, says that these instruments have more than paid for themselves in three months by the reduction in the number of lamp renewals.

THE Grand Central station, in New York city, was formerly lighted by 1400 incandescent lamps on 110 volt circuits. Since 1890 these have been gradually replaced by low-tension arc lamps, placed two in series, until at length all the incandescent lamps have disappeared. It is found that 90 arc lamps, consuming 360 amperes, give at least five times as much light as did the 1400 incandescents, consuming 700 amperes. The outgoing-train house, which has an area of 144,000 square feet, is most satisfactorily lighted with 32 arc lamps, which supplanted something like 500 incandescents.

SOME time ago, the General Electric Co. established at its works in Schenectady a student's course of instruction in electrical engineering, intended for young men who have had at least three years, experience in electrical or machine-shop work, or who have obtained from some technical institution the decree of civil, mechanical, or electrical engineer. At first the company felt compelled to exact a fee for admission to this course, but experience soon demonstrated that this had the effect of excluding the very kind of men who were likely to be of most value to the company—those who had worked their own way through college, but who could not afford to pay the fee, and hence the requirement was abolished. The object of the course is to give the student a thorough practical knowledge of the various processes through which a piece of electrical apparatus is carried while in course of construction, and also of the electrical and mechanical principles involved in the different operations. He is placed for a stated time in each of the departments of the works, in which he is required to perform actual work under the supervision of the foreman, and receives such instruction as will enable him to do so. The time occupied by the complete course is ordinarily expected to be about two years, and the learner is paid at rates varying from 8 to 17½ cents per hour, according to his experience and proficiency. The students are required in all cases to observe the same rules and regulations as the regular workmen respecting conduct and hours of work. It is stated that the complement of students is at present filled, and that there is likely to be no vacancy during the present year.

IN a small electric-lighting station at Allegan, Mich., two direct-current 25-kilowatt generators are driven by a 60-inch turbine on a vertical shaft, by means of a quarter-turn endless belt. The belt is 16 inches wide and 70 feet long. Two idler pulleys are set in a movable frame, each at an angle of 45°, and the slack of the belt is adjustable by a hand-screw which moves the frame. The device has been in use for some time and has given the most satisfactory results, being found to be far superior to the bevel-gearing ordinarily used under similar conditions.

THE John A. Roebling's Sons Co. (of Trenton, N. J.) have furnished 500 tons of copper wire for the new Atlantic cable now being laid by Siemens Brothers under a contract with the Mackay-Bennett Co., which, so far as we are aware, is the first instance in which American manufactured material has been used in any of the transatlantic lines. The average of all tests, 99.4 per cent. Matthiesen's standard, shows that a superior quality of metal was used. The wire actually shipped averaged 99.87 per cent., a figure seldom reached in so large a quantity. The same firm supplied the copper rods for 500 additional tons of conductor for the same cable, which was manufactured in England.

A TELEGRAM from New York to New Zealand traverses a length of line of 19,123 miles, nearly three-fourths of which is submarine cable. It has to be repeated or rewritten fifteen times. The longest cable is between America and Europe, say 2800 miles, and the longest land line is across Australia from Port Darwin to Adelaide, 2150 miles. When the Australian merchant finishes his day's work he can telegraph to London, knowing that the London merchant is beginning his day's work and will have all day to attend to it, and that he may expect a reply when he opens his own office again in the morning.

A SMALL central-station installation which exhibits some new features of interest is now in successful operation at Peterborough, N. H. The power is derived from turbines located about four miles from the center of distribution, from which a 2000-volt alternator supplies current to large reducing transformers wound especially for the local distribution. This is laid out on the ordinary three-wire system, and enables lamps of either 52 or 104 volts to be used.

A WELL-KNOWN electrical engineer says: "I know of one electric street-railway in this country whose cars are always fresh, neat, and clean, and which has even gone to the expense of putting a clock in each car as well as a mirror at each end thereof. The result is that this road has gained a larger patronage in proportion to the number of inhabitants in the district served by it than any other road in the country; the stockholders are pleased with the road; the patrons are pleased with it; and the general manager does not have a fight on his hands every day of the week." This statement furnishes much food for thought.

IT is probable that Fifth avenue, New York, is now the finest example of an electrically illuminated thoroughfare in the world. At each cross-street corner is an ornamental iron post carrying two low-tension arc lamps of tasteful design, fed from the ordinary house-service mains of the Edison Illuminating Co., and another similar post is placed in the center of each block, making in all eighty lamps per mile. The effect is most artistic, brilliant, and beautiful. The original installation of the system was mentioned something over a year ago, in these notes, but more recently the number of lamps has been doubled and the effect greatly enhanced.

ONE of the best materials yet tried for underground conduits for electric wires is wood-fiber treated with an insulating and preservative compound, so as to form a dense, hard substance. The fiber is formed into tubes of five feet in length and of any diameter from one to twenty-four inches by an ingenious machine recently invented for the purpose. Couplings, fittings, and section-boxes are made of the material. The prepared wood is a perfect non-conductor of electricity and heat, and, when laid in the ground, is much more durable than iron, being unaffected by either acids or alkalies. One advantage, which will be appreciated by electricians, is that the material is easily cut by ordinary tools, so that joints or fittings can be inserted at any point where it is desired to connect a branch.

SEVERAL years ago an arc-lighting plant was installed at Oswego, N. Y., in which the dynamo was driven by a large turbine-wheel, controlled by an ordinary ball-governor. A considerable amount of other machinery was carried by the same wheel, which added to the unavoidable irregularity of the load. Much trouble was at first experienced from the burning-out of switches, lamps, dynamo-fields, and armatures; the cause of which was ultimately traced to the excessive speed attained by the turbine under a sudden diminution of load, before the governor had time to act. Acting upon the advice of an expert, a heavy fly-wheel was attached between the turbine and the dynamo, which had the effect of removing all the annoyances arising from the cause referred to.

THE most serious problem confronting the managers of the electric railway systems at the present time, and in the immediate future, is beyond question that of the destructive effects of the powerful electric currents used in that service upon the vast network of metallic pipes for the distribution of water, gas, and electric cables which lies beneath the surface of the ground in all our large cities. The first investigator who called attention to the seriousness and unsuspected extent of this danger was Mr. I. H. Farnham, of Boston, and the results of a long series of experiments and tests were given in an exhaustive paper read by him a few weeks since before the American Institute of Electrical Engineers. Specimens of corroded pipes of lead, cast-iron, and wrought iron were exhibited, and cases were mentioned of iron water-mains which had been almost completely destroyed by electrolysis within less than six months. Some of the worst cases of corrosion which have been discovered in Boston were found to have been due to a difference of potential of only 1½ volts, and it has been experimentally determined that a difference of so little as 1/100 volt is quite sufficient to produce the action, either upon lead or iron. This circumstance indicates that the evil cannot be overcome by the application of the often-proposed remedy of increasing the conducting power of the return circuit by the aid of special conductors. Mr. Farnham concludes that while very much may be done to diminish the intensity of the action, its effectual elimination is still an unsolved problem.

A STATISTICAL table of the electric railways now in operation in Europe has recently been published, from which it appears that at present Germany occupies the leading position in this field. The figures of length of track and power used are given as follows: Germany, 102 kilometers and 2934 kilowatts; England, 71.4 kilometers and 2993 kilowatts; France, 414 and 1796; Austria-Hungary, 33 4 and 1115; Switzerland, 23.6 and 706. The total number of lines is forty-three, having an aggregate length of 305 kilometers; total station-capacity 10,654 kilowatts; number of motors and motor-cars 538; number of trail-cars 151. The overhead system of distribution is much more largely used than any other, and a considerable number of the plants are of American construction. There are about twenty-four additional lines in progress which are expected to be running before the close of the year.

THE general conclusions reached by Mr. Farnham may be summarized by saying that all single-trolley electric-railway systems employing the rails as a portion of the circuit inevitably give rise to the electrolytic corrosion of buried pipes in their immediate vicinity; a fraction of a volt in difference of potential between a metallic pipe and the damp earth in contact with it is sufficient to induce this action; the provision of a return conductor, even when equal in conductivity to the outgoing line, is without avail to wholly prevent damage to pipes; it has been found advisable to connect the positive rather than the negative pole of the dynamo to the trolley wires; and, finally, a conductor of large capacity extending from the grounded end of the dynamo, entirely through the district affected, and connected every few hundred feet to such pipes as are in danger, will usually secure their protection. Connections between the pipes and the rails or the return conductors at points outside the affected district should be carefully avoided.

A VERY interesting example of electrical power-transmission has been installed in connection with a large cotton-mill recently started by New England capitalists at Columbia, S. C. The length of line being only 800 feet, and the head of water but 25 feet, two special slow-speed tri-phase generators, of 500 kilowatts capacity each, were specially designed for the service. In order to gain the advantage of direct coupling to the turbines, these were necessarily made of unusual size and weight. The armatures are of the iron-clad type, and are ten feet in diameter. The speed is 108 revolutions per minute, giving a frequency of alternation of 36 per minute. Two pairs of 48-inch horizontal turbines furnish the motive-power. The conductors are carried underground in a plank conduit. The machinery of the mill is driven by seventeen 65-horse-power motors, hung overhead, and driving separate sections of line-shafting by direct belting. The motors are speeded at 535 revolutions per minute, and vary in speed less than 2 per cent. between load and no load. In addition to the motors, several hundred incandescent lamps will be operated within and about the mill. It will be observed that this is one of the first instances in practice of the application of power distribution or subdivision in textile manufacturing, and the results of this undertaking may not unlikely mark the beginning of a complete revolution in the existing practice in that department of mechanics.

ANOTHER phase of this problem, of somewhat startling significance, is pointed out by H. C. Cushing, Jr., in a recent communication to the *Electrical Engineer.* Mr. Cushing states that he has found instances in which a large difference of potential existed between two pipes entering the basement of a city building at points less than a foot apart. In one instance, with a piece of hoop-iron, an arc was drawn between two such pipes, by which a bunch of waste was ignited. In another instance, two pipes were so close together that the movement of the elevator caused sufficient vibration to alternately bring them into contact and separate them, causing a small electric arc every time the contact was interrupted. If this had not been discovered, a hole would ultimately have been made in the gas-pipe, and the escaping gas would have been ignited by the arc with the usual disastrous results. These dangers are enormously increased by the fact that many persons have discovered that they can secure an abundant supply of electricity free of expense for operating bells, gas-lighters, and even small motors, by simply attaching their wires to the gas- and water-pipes on their own premises. An increase in the difference of potential from any accidental cause is of course liable to convert such an arrangement into a most dangerous incendiary device. No doubt many of the fires which originate from unknown or at least unexplained causes are in fact due to some such condition of affairs as that pointed out by Mr. Cushing.

THE Postal Telegraph Cable Co. has fitly celebrated the semi-centennial anniversary of the opening of the first telegraph line between Washington and Baltimore, which took place in May, 1844, by taking possession of the magnificent building which has been constructed especially for its occupancy, on Broadway, New York city. The building is fourteen stories high, the basement and first floor, as well as the eleventh, twelfth, and thirteenth, being devoted to the uses of the telegraph company. The new building contains many novel features, some of which mark a notable advance in the administrative details of the telegraphic service. The electric current for operating the wires is derived from machines called dynamotors, which are in fact a combined dynamo and motor. They are driven by currents derived from the ordinary incandescent lighting street-mains and may be made to give out currents of any voltage required in the telegraphic service. The main operating-room is 70 by 156 feet in area and 18 feet high, and will accommodate over 300 operators. An interesting feature is that nearly all the operators of this company have accustomed themselves to copy received messages upon the typewriter, which has proved to be much more expeditious and accurate than the old method.

IN view of the reported decision to install a section of the Siemens electric conduit railway in the city of New York, the results of the operation of the Budapest system, to which we have heretofore called attention in these notes, is of interest. Twelve million passengers were carried in 1893; the receipts were about $500,000, permitting the payment of 8 per cent. upon a capital of $2,000,000. More than 100 cars are now running in Budapest.

IN the Ponemah mills, at Taftville, near Norwich, Conn., a different plan has been adopted from that just described. Two Corliss engines have been replaced by two tri-phase synchronous self-starting motors, of about 250-horse-power each, leaving the belting and shafting of the mill practically unchanged. These are driven from generators installed in the basement of the old Sprague mill at Baltic, 4½ miles distant. The generators and the motors are alike. The former are belted to a main shaft driven by three pairs of 42-inch and one pair of 27-inch turbines, under 32 feet head. The Norwich street-railway system is operated by a railway generator located at the Ponemah mill, which is belted to one of the tri-phase motors above described. The manufacture carried on is that of fine cotton goods.

ARCHITECTURE

Conducted by Barr Ferree.

MR. THOMAS HASTINGS is the only gentleman we know who lives in the fifteenth century. That he lives in the era named is, we gather from the interesting article he contributed to *Harper's Magazine* for May, his own belief, and it would be unfair not to accept his opinion on a matter that so closely concerns himself. Mr. Hastings needs no introduction as a supporter of the Renaissance. He has shown us, in a thoroughly masterly way, just what may be done with it under certain conditions, and, with equal directness, has shown us just what not to do with it. He speaks, therefore, with the power of authority, and his paper on "The Relations of Life to Style in Architecture" not only is interesting in itself but is entitled to the most respectful consideration. Mr. Hastings's position is that we must "recognize our true historic position and the principles of continuity in history," and, therefore, "we should study and develop the Renaissance and adapt it to our modern conditions and wants, so that future generations can see that it has truly interpreted our life." We should think that the effect that architecture might have on the living generation would be more important than its esthetic effect upon generations to come. But this is not the point of the discussion, which is our "historic" position in regard to the architecture of the Renaissance. By the Renaissance Mr. Hastings means all architecture done in the last four hundred years, "whether belonging to the period of Francis I, Henry IV, Louis XIV, or the Empire." It is impossible to deny the breadth of this definition, for it includes everything from the time of Francis I, though in it Mr. Hastings shows his French training, since it ignores the beginnings of the Renaissance in Italy and treats it as a purely French movement. As the spread of the Renaissance in France was chiefly a matter of fashion, the cultivation of a new taste by the French sovereign and his court on their return from the Italian wars, we are astonished that a writer who makes so much of his historical position should ignore this fact. Renaissance architecture, we are given to understand, survived almost up to the present time, when revivals of medievalism set in. In other words, we presume, a style that survived the artistic depths of the seventeenth and eighteenth centuries, that lived brightly and merrily in the early years of the nineteenth, came to a sudden and untimely end because, forsooth, a few architects undertook the so-called Victorian Gothic. It is always the unexpected that happens, and it is not unnatural, perhaps, that the lusty style that withstood so much should at last succumb to the most trifling ailment.

MR. HASTINGS'S paper proceeds on the assumption that all architectural styles are dead save the Renaissance. That is still alive, or, if dead, is so recently deceased that it is possible to resurrect the corpse without great exertion. If this is so it must be a matter of belief, since the Renaissance architecture of the fifteenth and sixteenth centuries, to go back no further, is surely as dead as Tiglath-Pileser II. The architecture of that time was succeeded by feeble imitations, which simply announced the end of the former epoch and did not in the least proclaim its vitality. And there have been successions of styles, real and imaginary, since then, the present Renaissance revival being simply a fad that differs only from other fads in being conducted and practised with more earnestness. The present age is wholly different from any any previous age, though Mr. Hastings does not appear to think so. It is an age of science, of mechanics, of engineering, of money-getting and money-making on a new and improved fashion, the like of which was never seen before. These are the things that make our life, and if style is the reflection of life in architecture they must appear in our buildings, as other life-elements have appeared in the buildings of other times and peoples. Mr. Hastings would have no reproductions of medievalism in this modern day; but he cannot have too many reproductions of the Renaissance. He tells us the Victorian Gothic failed because the life of the time was not Gothic; he avers that the Renaissance will succeed because we live the same life. Yet he must know that every time he looks out of his office-windows at the cable cars he is looking upon a phase of life quite different from anything known before. But however one may differ with Mr. Hastings as to his historic position, as to his views of life, as to his own favorite style of architecture, it is impossible not to feel his earnestness, not to realize that he thoroughly means what he says and speaks from profound conviction. The Renaissance with him, for this day, is neither a fashion nor a fad, but a stern, living reality. He is not thrusting his personal likes and dislikes upon the world in this paper, but explaining what he believes and why he believes it. And this he does in so delightful a fashion that one almost wishes one could agree with him in the positions which he maintains.

NOT very long ago a certain architect whose design for a high office-building was passed over by a building committee in a notable competition—though a very good design, it may be remarked—got up in public meeting, a few days after the announcement of his lack of preferment was made known, and remarked that it would be better to build no more high buildings in the city of New York. As the author of this remark had, in the course of an extended practice, erected many high buildings—some, it must be confessed, quite inferior to the aforementioned design that failed of acceptance, though not of excellence—his unexpected utterance attracted an attention quite disproportionate to its importance. There may have been, and probably was, an accidental sequence in these two things, but such is the origin of an outcry against high office-buildings that has come from the mouths of many New York architects. The self-sacrifice involved in this campaign is enormous. High office-buildings are the most lucrative form of work that now comes into architects' offices; if a law is passed forbidding them the architects will be the first to suffer. Yet a number of these men are now posing as very noble advocates of a measure affecting the health, comfort, and safety of the metropolis of America. Perhaps there is some truth in what they say. The modern high office-building is a thing of unknown horrors. Though methods of construction are improving each day, though new devices are constantly being invented that will render them safer and more profitable, no one will venture to say just what would happen in case of fire. It is to be hoped no one ever will know, and that no great calamity will visit them or misfortune happen to them. It is an undeniable fact that a narrow street full of very high buildings would be a most dreadful thing. On the other hand, it ill becomes the designers of high buildings that ought not to be seen under any circumstances, to agitate for wider thoroughfares, or take any other steps which will make them more visible. The narrow streets of New York, darkened as they already are by some high buildings, have been blessings in disguise, since they have effectively prevented the hideousness of many lofty buildings from being seen. The question of unhealthiness is also not wholly without foundation, but every engineer will admit that the science of ventilation is still largely in its infancy, and it is an unquestioned fact that many business buildings not noted for their altitude are conspicuously bad and dangerous places to work in. It cannot be denied, further, that rows of high buildings will darken rows of other high buildings placed on the opposite side of the street. But the moment this becomes apparent the continued erection of these structures must receive a set-back. Real-estate owners cannot go on erecting structures that have a damaging effect upon adjacent buildings.

AND the real-estate interests in New York, and in every large city, are more powerful than the utmost volume of architectural opinion. The present high values placed upon commercial property in land are very largely due to the ability to construct high buildings upon small sites that practically increase the renting value of the land. Remove the ability to do this and a great shrinkage immediately occurs in the value of land not already occupied by high buildings, with a consequent artificial increase in the value of property of that description. The latter change is, perhaps, not to be deplored, since every property-owner is anxious for his property to increase in value, whatever the cause may be. But certainly any movement that looks to the lessening of real-estate values by legislation will meet with powerful antagonists. The self-sacrificing labors of the architects will be as naught. They will have ventilated a hasty opinion, since only opinions are available against the merits of high buildings; there are no facts at hand. They will have posed as public philanthropists. They will have placed themselves against the wishes of their most profitable clients. Apart from these results, it is difficult to see what will happen from an agitation against the high building. Now if, instead of bringing up this entirely new question, the architects of New York were to argue out the question of the architectural expression of the modern high commercial building, the greatest good might result, not only to themselves but to the public at large. The problem of design in the high building is very largely the same in a great many instances. There is no reason at all in the nature of the case why certain general principles should not be formulated and the problem worked out on a single definite line. Even if the mode to be followed should not be the best it would at least be a step in advance in suggesting work in one direction, and when a number of architects get down to that way of doing things excellent results are to be expected. By all means, gentlemen of the architectural profession, consider the question of the high building, but keep within your own proper limits.

THE American Institute of Architects has appointed a committee to draw up a code of regulations concerning competitions, and suggestions are invited from all architects upon that subject. So much space has been given to this topic in these pages that it seems scarcely necessary to refer to it again, but the appointment of this committee is a sign of the times that cannot well be overlooked. Competitions have now become so important a feature of the architect's work that it is entirely incumbent upon the most important architectural body in America to decide how they shall be conducted. This is the very point on which the greatest divergence of opinion exists, and it is to be hoped that the Institute will succeed in devising a code that will meet with the entire approval of the profession. It would be a pity if this committee should not find it within its scope to determine the advisability of competitions at all. These trials of ability are so common that the busy architect must devote a great deal of his time to competitive work if he would keep his office full. It seems scarcely possible that such a condition of affairs should be permanent. The burden it entails upon architects must, before long, become so great that none but the very youngest architects, who have nothing under the sun to do, can afford to go into them. Whether, when this becomes reality, we shall see the work leaving the offices of the older men for the younger, remains to be seen. Meanwhile it appears eminently proper that architects should most carefully consider the ultimate end of the competition craze. That it is such no unbiassed man can deny, and we do not see how architects can get away from the appalling situation they may find themselves in when the present movement is pushed to its furthest logical development. Before drafting any rules for the guidance of competitions, it would seem to be the first business of the committee to determine whether competitions are desirable, whether the work they cause the architect is compensated for, whether the mental strain, the raising of hopes, the dashing of expectations, the dreams of success, the sorrow of failure, the wire-pulling, the exerting of influence, the personal equation, the obtaining of votes, the hundred-and-one elements which help to decide a competition (to say nothing of the relative merits of any individual drawing);—it would be well to decide if all this pays and if it is desirable to bolster up the system that rests on such a multitudinous basis. Then if the committee will give the reasons why competitions are desirable or undesirable we will have a document that may be looked upon as a standard, and which will serve as the basis of later regulation and arrangement. Otherwise we do not see how the committee can avoid the summarizing of the whole subject in a few brief rules, very much like the following:

Rule 1.—No building shall be erected unless the design shall be chosen by competition.

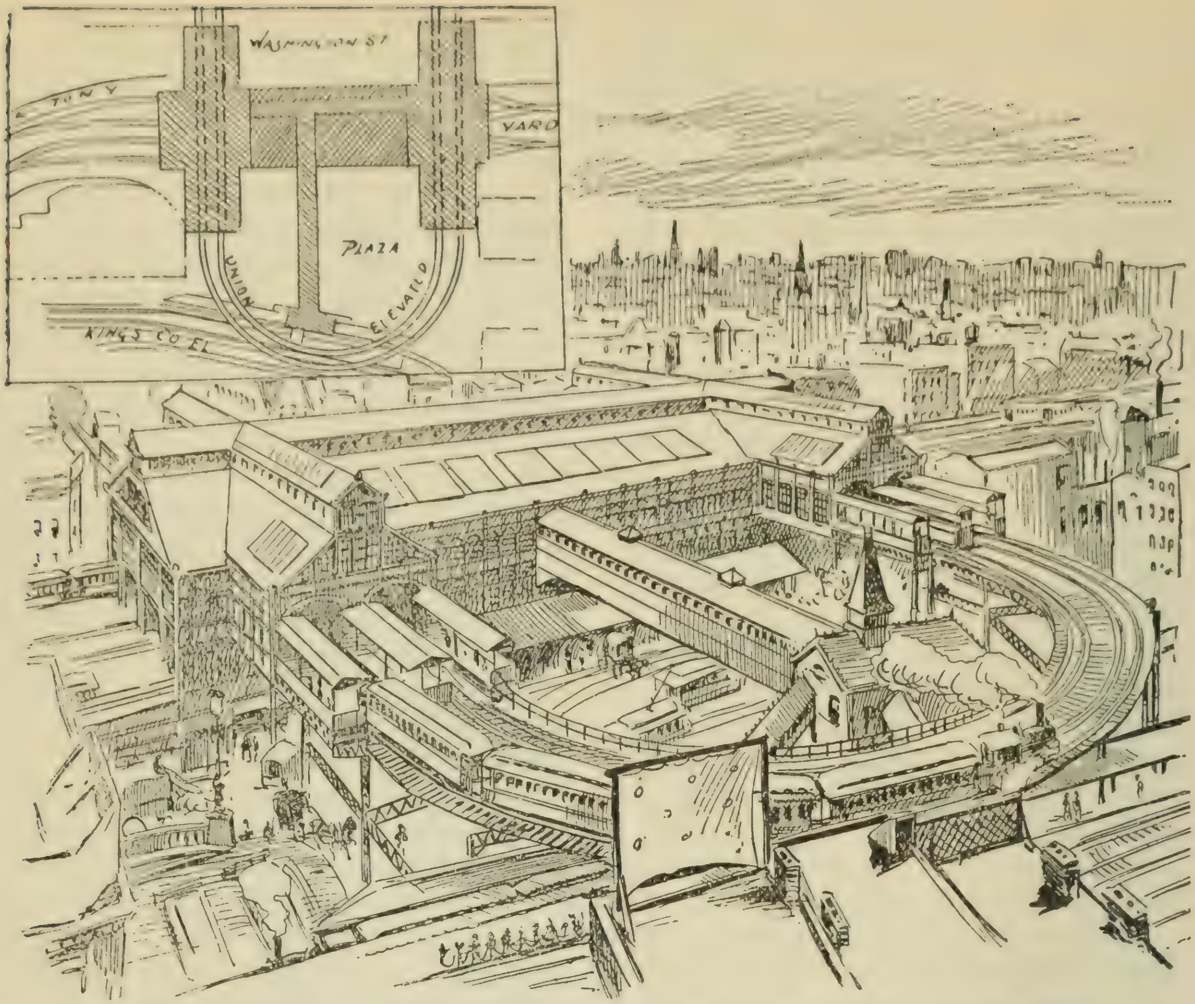
Rule 2.—No competition shall be held unless all the competitors are duly compensated for their labor.

Rule 3.—Uncompensated competitors shall be ruled out.

Rule 4.—Every design submitted by a paid competitor shall be declared the best and chosen for erection.

Unless rules somewhat on these lines are formulated it will be impossible to avoid the heartburnings, the discontent, the dissatisfaction, the disgust which is rapidly souring the tempers of very good architects through the competitive system. And an architect with a soured temper is no better off than a man with a balky horse. We must admit we have no idea how such rules would operate in practice; we are not concerned with that. Our position is that, as competitions were invented by the architect for his own personal advantage, nothing short of such rules will be acceptable.

THE picture on the following page is not a view in Philadelphia, or in Nankin, or in Timbuctoo. It is neither a caricature nor a glimpse of architecture a hundred years hence. It is simply a very rough sketch of the proposed new terminal-station in the city of Brooklyn for the New York and Brooklyn bridge. It is a scheme the like of which cannot be duplicated in the civilized world, and, as it is actually proposed to carry out this work on the lines here illustrated, Brooklyn will soon be possessed of the greatest architectural wonder of the globe. Heretofore Brooklyn has chiefly been famous as the scene of the oratorial contortions of pulpit orators; when the Bridge Station is finished it will possess an inextinguishable curiosity that will permanently eclipse all other attractions, actual or to come. Imagine, if you can, a city paying out $2,000,000 of good solid public money for the purchase and creation of a public square and the laying out of a fine, broad avenue, and then permitting certain private personages, who have contributed nothing at all to the cost of these improvements, to deliberately seize this public property for their own individual personal aggrandizement. Yet this is just what has been done in Brooklyn in the year of grace 1893–94, and the general effect of this operation is shown in the sketch. In the background rises the huge bulk of the terminal-station proper—a vast ugly bare frame, designed without the smallest pretense of architectural discernment, planned without regard to the convenience of passengers; a structure almost shapeless in its hideousness; cold, stupid, horrible, inane. From its two ends emerge the ends of a huge semicircular encumbrance, lifted high up in the air where it may be seen by all men, and having for its single use the convenience of an elevated railroad corporation that has been shrewd enough to take public land for its own convenience. This semilunar structure entirely surrounds the costly plaza paid for by the city of Brooklyn, which thus becomes of no value at all. But in case there should be doubt, its ruin is emphasized by a *pons asinorum* that shoots suddenly across the center to suit the convenience of another elevated railroad. It is a most serious public misfortune that public taste and enterprise in Brooklyn are at so low an ebb that the possibility of obtaining a really noble entrance to that most noble of New York structures, the great East-river bridge, should have been so wantonly ignored.

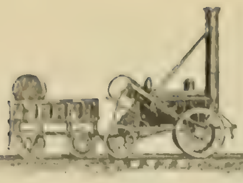


BROOKLYN PLAZA, AS IT WILL APPEAR AFTER THE RAILROADS ARE IN POSSESSION.
[Reproduced from "Harper's Weekly" by permission. Copyright, 1893, by Harper & Brothers.]

It is a scandal that public officials should be retained in salaried positions at the public's expense who could think of such a preposterous plan. And more than all it is an outrage that, with so faulty a plan, the utmost effort should not have been made to have clothed it as decently and as orderly as possible. But there has been no attempt to do this. The plans and elevations of the station are miracles of incompetency and absurdity. Engineering never so boldly confessed its own weakness, nor has the engineer more freely admitted his inability to cope with questions that belong quite as much to the architect as to himself, if not more.

WE are pained and surprised to learn that, notwithstanding its eagerness to obtain recruits, the Society of Beaux-Arts Architects of New York has as yet formulated no initiatory ceremonies, whereby the self-consecrated candidate for Frenchite orders is set apart from the ordinary herd of mankind. This is a most serious omission, and we trust that it will soon be remedied. The Frenchite architect is the salt of the earth, and it is entirely becoming that he should be formally marked as belonging to that consecrated class. Pending any action by the Society on this point, which we should have supposed would be one of the first things to command its attention, we venture to outline a little ritual of our own as eminently suitable for the solemn occasion: The members, clad in genuine École blouses heavily stained with genuine Parisian ink, will receive the victim (this, being a shorter word than candidate, is used as more convenient; no suggestions intended). Each member will be armed with the sacred T-square and provided with his self-blowing horn. The victim, clad in his ordinary garments, will be introduced in silence. Then, while his outer upper garment is being removed, the Society will sing the consecrating hymn "To Paris" (pronunciation *à la française,* if you please). The president will then, by means of a speech in the purest of Écolian French (of which the victim will understand not a word), seek to impress upon the young man the solemnity of the occasion, the importance of the Society, the sacred nature of its work, and other notable questions, casually alluding to the duties that will await the victim in Paris. The chief feature of the "effacement" ceremony that will follow this will consist in injecting a special brand of Frenchite Keeley-cure into his right arm, which will have the double advantage of causing the victim to hate all manner of strange thing in Paris, save Frenchite modes, and will render his right hand incapable of drawing any save genuine Frenchite designs. After this will come the clothing of the candidate with a snow-white blouse, which is to be worn constantly when in Paris, and the presentation of the self-blowing horn, warranted to take up the story of its owner's greatness should he, by any means, cease speaking of it himself. Various other details may be added according to the taste of those most concerned. We should think that these might form the essentials of the ritual, and, in an organization composed of so many skilled designers, it would be possible to embroider a positively beautiful formula upon it. An important feature would be the presentation, by the vice-president, of his famous ethical work "On the method of designing in the ancient Italian style by means of deceased architects."

THE *Architectural Review,* we understand, reaches a refined, cultivated, cultured circle of readers. Trustworthy as this statement probably is, we doubt if its readers can long stand the strain put upon them by some of the topics suggested in its editorial pages. In a recent number it brings up before its R. C. C. Circle a profound problem concerning the seriousness of this Department. "We are somewhat doubtful," it writes in sonorous phrases, "if the Architectural Department of THE ENGINEERING MAGAZINE is to be taken seriously." This truly is a masterful problem, and, if the editor himself cannot understand it, we do not see how his readers are to make it out. Still we suppose it is natural that, meeting an apparently unanswerable problem, one should seek a solution at every available source, and we trust that the *Review* will lay before us the results of its appeals for information. Of course there can be but one true answer to such a question, and we are amazed that the *Architectural Review* should have any doubts on the subject. We should have no objections to answering this problem ourselves in its columns, but we really must decline to burden our own pages with a topic on which we hope our readers need no light. We think, however, that we may be permitted to state that our views of current architectural conditions are necessarily somewhat limited by the horizon of New York. The architects we meet, the clients we hear of, the conditions we are most familiar with, are those of New York. It may be different in a great center like Boston. We do not know Boston as we should, though we must leave the *Review* to decide if what is our loss is Boston's gain. Clients and architects may be different there. It is possible that architects, in their eagerness to serve their clients, may despatch their own carriages to bring them to their doors. Such a custom is, we are sure, unknown in New York. But it may be the custom in Boston. We repeat this is our loss; apparently there are advantages to be gained in surveying architecture from the neighborhood of Boston harbor that are not known to those whose horizons are limited by the contracted area of New York, and the small narrowed life contained therein. We are astonished that, with its wide, glorious, free vantage ground, with its enviable point of view, and its unsurpassed opportunities, the *Architectural Review* should have deemed it necessary to open a department in its columns especially consecrated to ourselves. Surely there are mightier problems in architecture to discuss than this, greater truths to expound than our conviction of error, grander work to do than expressing surprise at what we may choose to say.



RAILWAYS

Conducted by Thomas L. Greene

THE complications which have arisen in the affairs of those railways which are in the hands of receivers, and the conflicting statements put forth by committees representing the various issues of bonds and stocks, have brought into clearer relief the necessity of possessing full and accurate information about the affairs of all corporations. Bookkeeping, it may be observed, is not an exact science. Its *purpose* is to express the conception held by those who control the entries. There is no miracle-working power in the art of accounting which can automatically disclose a danger-signal. Just as two persons in describing an incident will use language which may state the facts correctly, but which will give a different coloring to the occurrence according to the interests or prejudices of each observer, so bookkeeping can only reveal the views, whether reckless or conservative, which the officers of a corporation may hold regarding certain business facts; for illustration, much of the modern system of corporation finance depends upon the distinction between charges to income and charges to capital. Charges to income affect the earning power of the company and may alter the amount of bond interest or dividends to be paid for the year. It is natural, therefore, that the officers of a corporation who are anxious to make a record for successful management of the property over which they have been put in charge should decide a doubtful question of expense in favor of a debit to the capital rather than to the income account; and, indeed, with the best of intentions it is often very difficult to draw the line. Unscrupulous men may take advantage of this general doubt and so make up the accounts of a railway as to show and to pay large profits, while the real fact may be that unearned money is being distributed to shareholders with the result of forcing bankruptcy at the first pressure of hard times. The same remarks may be made about the need of allowing for depreciation and renewal of plant or equipment.

THERE is all the more necessity, then, of furnishing to the public statements in full detail of all the operations of railway and other corporations in order that bond- and stock-holders may form a judgment of the real condition and earning power of their property, independent of all opinion of their managers. Corporation reports which show only the aggregate figures of earnings and expenses are useless to any investor who wishes to have some knowledge of the company in which he is interested. We are living in an era of corporations. The corporationizing of our carrying and manufacturing industries has proceeded rapidly of late, and when better times return again we shall undoubtedly see other companies formed. So long as a business is conducted by a partnership the public have no interest in its private affairs. How the partners keep their books is a matter of no concern to others. This consideration is subject to slight modification when such a partnership is turned into a corporation whose shares are all held by the late partners and not offered to the public. In such cases the public have a right to ask only for such information as is commensurate with the advantages of the corporate form granted to the partnership by the state. That is to say, in return for the freedom from personal liability for corporation debts, it is right that the corporation officers should make such statements of their affairs as shall give the creditors a fair notion of the financial standing of the company to which they are loaning money or selling goods on credit. This statement, however, need not go to the length of declaring the profitableness of any industrial or trading concern, since with that the creditors and the public are but remotely concerned.

THE case is at once altered, however, when the bonds and shares of such a corporation are offered for sale publicly. Shareholders of a company, whether a railroad or a manufacturing corporation, are really partners in the enterprise and are entitled to know the true condition of their property. The moment a man is asked to invest his money in a business, that moment he is justified in demanding full particulars. It is true that in the past many have bought bonds and shares with little or no inquiry, but that state of things is passing away. Banking-houses which have a reputation to lose are no longer taking the chance of destroying their business by recommending investments which are filled only with air promise-crammed. Particularly is this truth brought out by the conflicting plans for reorganization of insolvent companies put forth of late. Where a stockholder is asked to pay an assessment upon his shares, or a bondholder to scale down his interest and principal, when perhaps he had expected golden returns from his investment, such an investor is apt to ask questions regarding his corporation which he ought to have asked long ago. But the lesson, though bitter, is likely to be thorough, and thus corporations which in the future shall decline to give full information regarding their affairs will be made to feel the effects of their bad policy by a lower range of quotations upon their securities and by restricted markets.

THE arguments for full corporation reports are, in the case of railways, greatly strengthened by the semi-public position of those companies. Nothing is better settled in our law than that in return for privileges like that of eminent domain our common carriers owe duties to the shipping and traveling public which must be fulfilled. If these carriers are to be made subject to restricted or regulative legislation of any kind whatever, it is of the first importance that this governmental control by legislation should be based upon accurate knowledge. The work of the statistician of the interstate commerce commission, though subject to criticism in part, has been of great value in forcing upon our railways the necessity of publicity in their accounts, and of accuracy and uniformity in the methods of accounting employed. Reforms of this character do not go backward, and we may expect hereafter better information on the earnings and work of our corporations.

THERE has been lately discussion about the affairs of a prominent company which involved some of the most serious questions in our corporation finance. The Delaware and Hudson Canal Company is an old corporation which was formed originally to own and to work some anthracite-coal lands in Pennsylvania, including a canal to the Hudson river as a water outlet for the coal. In course of time railroads were added by lease or ownership, until now the railway department of this company is as important as the mining department, while at the same time furnishing an outlet for the coal. The Delaware and Hudson has paid regular dividends of 7 per cent. Some $5,000,000 of bonds maturing next October, it was proposed to issue stock to this amount at par to the present stockholders to take up these bonds. As the shares are selling at 140 or more, and as there is no doubt in the mind of the public of the continuance of this rate of dividend, the proposition involved the granting of a bonus of $40 to each subscriber of a new share. Not content with this premium, a minority of the board of directors of this company advocated the issuing of this new stock to old shareholders at 75, the plan being to take the other 25 per cent. from the treasury of the company. To this scheme the majority were strenuously opposed, and by appeals to the stockholders these latter gentlemen secured proxies enough to elect their own board of directors and carry out their plan of issuing the new stock at not less than par. The Delaware and Hudson Company carries in its balance-sheet an item of surplus dividend fund amounting to $7,000,000, and it was from this supposed fund that the minority directors proposed to take the cash necessary to retire the bonds. But this large sum is shown by the same balance-sheet not to exist in cash but to have been invested in assets of the company. With few exceptions these assets, while important to the company as a miner and carrier of coal, have no other intrinsic value; thus the canal, worthless for any purpose except that of transporting coal, is carried on the books at a valuation of $6,000,000. The New York and Canada railroad, a branch of the system which does earn interest on the outstanding bonds, is put down at $4,500,000. The significance of these figures will be appreciated when the business of the company as a producer of anthracite is considered. The coal in the lands owned by the company, according to a committee's report, will be exhausted in sixty years. Practical coal-men familiar with the territory do not think that the Delaware and Hudson supply will last as long as that, while no doubt the increasing difficulties of mining will make themselves felt in from twenty to thirty years. The $30,000,000 of capital stock of this company is invested in such assets as have already been mentioned, besides coal-lands and colliery improvements. Nearly all of these assets will become valueless when the coal is exhausted. What then should be the policy of a corporation whose end is, as corporations go, not very far off? In the light of the facts mentioned, not only should the company not issue new stock at 75, but the issue at 100 is of doubtful expediency. Ten-year bonds at 4 per cent. could have been sold to take up the old-7-per cent. bonds, and the 3 per cent. in interest saved could have been held as a fund for the retirement of the bonds at maturity; or, if the company wished to adopt at once a very conservative course, they could establish a sinking fund of 10 or 15 cents per ton on all coal mined: the money to be taken from the coal receipts each year and held as an offset to the gradual depreciation of the property. Such a sum per ton would just about cancel the capital stock at the exhaustion of the coal-lands. But present stockholders can scarcely be expected to take such a conservative view of their affairs, The motto of present holders is always " After us the deluge," even though the last holder should eventually lose the whole. But at least public opinion should keep corporations of this character from unusually reckless financiering.

It has been suggested in recent numbers of this Magazine that there was still a large field for engineers in the railway business, although it was remarked that our younger men could profitably direct their attention to those things of which the railways were in immediate need. This remark applies to other departments besides those of engineering proper. For illustration, it is confessed by all operating offices that the American system of collecting tickets on passenger trains is loose and uneconomical to the highest degree. This fact is proved, if proof be needed, by the efforts made at times to discover how things are running, and whether conductors are honest, by means of spies. That the system of employing spotters is a very crude way of attempting to cure the evil needs no argument. It substitutes spasmodic examination instead of a system, it gives the honest conductor very little chance to defend himself against a mistake, and it does not do much toward permanently curing the practice indulged in by unscrupulous passengers of dodging or cheating the station-agent or conductor. The compulsory showing of tickets at a station has done much, but that manifestly cannot cover the whole case. The Chicago and Alton railroad is trying an experiment on a small scale which will be watched with interest by all concerned with the matter of passenger revenue. In effect it is a system of turnstiles at particular points. Indeed, it has been suggested by some of our older officers that revolving gates for both ingress and egress should be established at every station, by which means an automatic register could be had of all travelers getting on and off the trains at each station. If such a record could be kept for a stated time it would form an accurate statistical basis for estimating the passenger business at one station and between all other stations. Then if tickets and cash did not come up to the number of passengers thus to be accounted for an investigation could be intelligently begun and the error or cheating quickly found. The main difficulty in such a scheme would not be so much the first cost—although that might be considerable—but would be rather the opposition sure to be developed on the part of the traveling public. Passengers will wait until the last moment before trying to catch a train, and if a number lost their train because of getting behind a large crowd, which the turnstile would allow to approach the train only one at a time, there would be such loud complaint that the railway officers would be forced to take notice of it. Large numbers of turnstiles at all stations would be out of the question, besides being very expensive. How, then, shall this problem of ascertaining the number of passengers and their journeys on our American railways be solved? Fame and a fortune awaits the civil or mechanical engineer who shall invent a system or an apparatus which shall yield such information as will enable a reform to be carried out.

BUT for the hard times we might already have seen an evolution in the business of carrying passengers upon the Great Lakes in connection with the railways. The Great Northern, under designs of its president, Mr. James J. Hill, has already constructed one steamer wholly and another partly. These steamers are for passengers only and are intended to make remarkably quick runs between Buffalo and Duluth, connecting at the latter point with the Great Northern system. There are now some fair passenger boats upon the lakes, and the trip is occasionally taken by tourists, but these boats also carry freight and are hindered in speed and accommodations by that fact. Mr. Hill's intention was to put on the lakes boats which in speed and comfort would rival the river and Sound boats running out of New York. By carrying first-class passengers without encumbering the boats with freight, President Hill believes that he could induce more tourists and capitalists to take the trip via the lakes and over his road; while emigrants could be carried on the same steamers who would help settle the vacant lands of the Northwest. Such a plan once put into effect might have important consequences upon the carriage of railway passengers on the lakes.

IN view of the timely note sounded in the May number of this Magazine, that American manufacturers must seek foreign trade, it is well to refer to a very important publication on the South American railways prepared by the Oriental Republic of Uruguay as a contribution to the World's Fair at Chicago. Those who are or should be interested in our trade with South America would do well to read first of all the admirable and comprehensive review of the general conditions of the railways in South America by Mr. Courtenay de Kalb, in the April number of this Magazine. This Uruguayan treatise contains a mass of most useful information and statistics bearing upon the same subject. The publication gives the details of the railway laws of Uruguay and the other countries, the government requirements, methods of tender, the concessions of the government and the like. It also gives tables of gradients, mileage of the railways, and distances between stations. A good condensed description is given of the nature of the soil and the kind of roadbed adopted as the standard, together with drawings of buildings and bridges as well as cars, sections of banks and cuttings. Tunnels are described, and also the workshops with their fittings. Mr. DeKalb said in his article that American rolling-stock is superior to any other for use on the South American railroads, and that European manufacturers modelled their equipments after United States patterns. In the Uruguayan treatise tables are given describing the equipment of these South American railways in full detail, giving type, number of cars, tare, load, class, name of maker, and year built for all the principal companies. Comparatively few American names appear in the tables as manufacturers of either locomotives or cars, but the description of this equipment is more full and accurate than can be found elsewhere. Don Juan José Castro, the Montevidian civil engineer to whom the Uruguayan government entrusted the compilation of this work, gives also tables showing the statistics of operation of these railways, the tons of different commodities carried, the train-miles run, the number of passengers, and other like figures. Good accounts are given of the railway systems of Uruguay, Argentine, Brazil, Chili, Bolivia, and Peru. The author recapitulates at some length the story of the surveys made for the Intercontinental railway, which some day may connect the United States with these South American countries. A good deal of space is given to the project called the Interoceanic railway, a line which Don Castro thinks would be commercially successful if built from Pernambuco, Brazil, down the coast through Rio Janeiro and Montevidio to Buenos Ayres, and thence westward over the trunk lines now building to Valparaiso. The tables quoted in the treatise show a theoretical saving in time and money over the all-water route from Europe to the River Plate cities.

The treatise gives valuable information on subjects connected with the commerce of South America. Through exceptional means of information, with careful estimates where accurate statistics were wanting, a valuable series of tables is printed giving the population of South America by countries and by provinces. Thus we find that the total population of South America in 1893 was between 39,000,000 and 40,000,000 of souls. Of the 15,350,000 inhabitants of Brazil, 14,836,179 persons lived in the states bordering on the Atlantic ocean. The mileage of railways per kilometer and per inhabitant are given and compared with similar statistics of the United States, the argument being that increase of railways would bring increase of population and business in South America as it has in the United States.

Finally, and very properly, the treatise shows modestly but clearly the important place which Uruguay must hold in any extension of the railway system in South America. The great drawback to such extension is the extreme diversity of the gages of the railways now built, for Mr. DeKalb is unquestionably right in stating that systems of railways will pay in South America where isolated lines will not. Don Castro takes pardonable pride in quoting figures of exports and imports per inhabitant of all the South American countries, Uruguay standing at the head of the list. A comprehensive review of the cost of the South American railways by countries closes the book. By this table, Peru has paid most dearly for its railways, owing to the exceptional character of the country. A fact in this connection of interest is that the railway projected by Meiggs, in a distance of 200 kilometers rises to a height of 4779 meters, the highest in the world, Mt. Blanc itself being but 30 meters higher. Brazil has constructed its railways at the smallest cost per mile, partly because the narrow gage predominates in that country. The author believes that American practice in construction and in operation should be followed in the South American countries, and that our policy is the only one which will induce the building of railways sufficiently to develop business and commerce in the southern hemisphere without too much burden upon the countries at the outset. To those interested in railway building, equipment, and supplies, this publication by the government of Uruguay will furnish detailed information about South America not otherwise easily available.

THE Pennsylvania Railroad Co. has issued a handsome catalogue of its admirable World's Fair exhibit. It contains a plan of the exhibit and two half-tones, one presenting a front view of the company's exhibition building and the other an end view of the building, with the "John Bull," one of the Krupp gun-carriages, and the bridge crossing the tracks.

MINING AND METALLURGY

Conducted by Albert Williams, Jr.

IN some of the older metallurgical treatises on steel, and also in some of the more complete of the recent ones, reference is made to the effects brought about by the introduction of small quantities of silver into the metal. Experiments had been occasionally made with silver-steel alloys, and the evidence seemed to show that silver improved the metal for certain purposes. This has always been regarded as a mere matter of curiosity in metallurgy, because the high price of silver would prevent its use in any quantity, however small in percentage, that could be shown to be effective. Some persons have suggested, as an explanation of the superior qualities claimed for certain iron and steel made in the Rocky-mountain region, the presence of silver derived from the ores. It is well known that small quantities of silver do exist in these ores, but the quantity is absurdly insufficient to give perceptible results. A few ounces per ton of ore may make quite a showing in values, but when reduced to percentages become insignificant. But now the suggestion is made, half in joke, half in earnest, that a possible extension of the use of silver may be found in this direction, and thus help out the painfully depressed silver market. The proposition is hardly feasible, taking as admitted the beneficial effects of the combination. One per cent. of silver would mean about 20 pounds per ton of steel, or say, at ruling prices, about $150 to $175 a ton in addition to normal cost. Less than one-half of 1 per cent. would hardly be noticeable in effect, if at all, but one-half of 1 per cent. would cost about $75 or $87.50 extra. The term "silver steel," frequently used, is of course only a trade-name for a certain brand of cutlery-steel.

THE cause of the breakage of stamp-stems is the subject of a very interesting discussion between Mr. W. L. Austin and Dr. R. W. Raymond in the transactions of the American Institute of Mining Engineers. Dr. Raymond having spoken of the "fable" of crystalization, the explanation so generally given and accepted at the machine-shops and by the mill-men, Mr. Austin argues, in favor of the old theory, that the fracture always shows a granular structure and that the fairly uniform life of the stems (a year, eighteen months, or two years at best) is accounted for by the length of time necessary to effect the crystalizing. Dr. Raymond points out that the fracture does not usually occur at the points of greatest vibration, that the appearance of the fractured surfaces may not be a proof of such crystalizing process, and suggests as a substitute explanation that the breakage may result from minute fractures between the iron particles uniting in course of time to form a larger break, when the final rupture takes place. Dr. Raymond also says that the crystalization theory may do harm by serving as an excuse for bad workmanship on the one hand and an acquiescence in the hopelessness of the case on the other. The question is by no means as simple as might appear. It reopens the whole subject of the crystalization of iron and steel as a result of long-continued jarring, the importance of which as a convenient theory seems to have lost ground of late among the authorities, among whom Mr. H. M. Howe, in his "Metallurgy of Steel," is inclined to shelve it. Unfortunately, the matter does not seem to be one which can be submitted to the test of direct experiment (unless the results in actual experience are to be taken as such), for it would be hardly practicable to devise a testing machine that would subject a specimen stem to just the jarring stress that comes upon it in actual service. The fact that the parts of broken stems after having been reunited by welding and thus repaired have a fair life seems to make against the crystalization theory, for if that theory is true as regards the point of fracture it ought also to hold good as to the whole stem; that is, that the metal would naturally be expected to be changed from the fibrous to the granular structure throughout its entire length, which is not the case. Some light would be thrown upon the subject by the behavior of steel rails, were it not that other causes, notably stresses engendered by change in temperature, complicate it. The great majority of mill-men who use, and the machine-shop managers who make, these battery stems certainly believe in the crystalization theory. But if it is correct, or rather if it is true as a partial explanation, it has probably been made too much of.

In a communication to this Magazine for May, Mr. Percy Williams takes issue with Mr. R. A. Parker's recent criticism (p. 761, February number) of the lesser mining schools, and suggests that the last-named writer has been affected by favoritism in implied commendation of the Columbia School of Mines; but falls into the exclusiveness of which he accuses Mr. Parker, when he says that "there are only three mining schools in the country to-day that take an active part in the education of reliable mining engineers and metallurgists—the schools at New York, Golden (Colorado), and Houghton (Michigan)." Surely the list might be extended to include the Missouri School of Mines, at Rolla; the South Dakota school, at Rapid City; the new Arizona school, the excellent courses in mining engineering at the Massachusetts Institute of Technology, Lehigh University, the University of California, and the Pennsylvania State College, to say nothing of the general technical schools like the Sheffield, at New Haven, the Rensselaer Polytechnic, at Troy, the Stevens Institute, at Hoboken, and several others which do not make specialties of mining and metallurgy, but furnish a groundwork for these branches. It is invidious to make comparisons. The views of this Department as to the whole question of mining education have been pretty fully ventilated in comments from time to time, and it would be wearisome to reopen the discussion in detail now. To sum up, *all* the schools do good work, more or less (generally less), according to kind and degree; and all of them are open to criticism on one side or another—some from disadvantage of position, some from lack of practical aim or misunderstanding of what is wanted, some from insufficient equipment, and some from "biting off more than they can swallow,"—to use a homely but very applicable phrase. But it is worth recalling, in this connection, that one prominent educator,—himself an engineer, not merely a pedagogue,—has written (p. 545, January number) that it is not his purpose to graduate *miners*, but *engineers*—which by no means indicates any depreciation of the practical side of the matter, but only a different way of looking at the purely educational side. No matter what the curriculum or the opportunities at the school, the young graduate will need practical experience afterward before he is fit to hold responsible executive positions, though a good school will have made him at least a fair assayer, surveyor, and draftsman, and therefore able to fill almost any subordinate position satisfactorily and at once.

At a recent meeting of the Engineering Association of the South, Dr. J. M. Safford described the phosphate-beds of Tennessee, which in the middle of the state occupy a definite geological horizon (Devonian) and cover a very wide area. In some places they are but a few inches thick; in others they run entirely into sandstone; while in some localities they seem to be a "bonanza." There are two distinct beds of phosphate separated by black oil-shale. The upper layer, seldom over ten inches thick, is a stratum of concretionary balls, kidney- and knee-shaped forms, from the size of a walnut to that of a man's head, sometimes loosely disposed and sometimes tightly packed together like cannon-balls. The lower layer is more important. In its best presentation it is a well-defined, continuous stratum, dark bluish or bluish-black, rarely gray, with fine or coarse grain, resembling a bed of stone coal, both in appearance and in the manner in which it will have to be mined. Its thickness ranges from a few inches to over four feet of good phosphate rock. The total available area, though large, is not definitely known. Dr. Safford states that there is not the same uncertainty about this phosphate that there is about the Florida rock, as by careful examination of the outcrop close estimates of tonnage can be made. A cubic yard weighs about two tons and the estimated cost of mining is $1 per net ton. Analyses show 60 to 75 per cent. phosphate.

ANOTHER paper presented before the same society, by Mr. Tyler Calhoun, describes the method of handling coal by gravity at the Whitwell mines of the Tennessee Coal, Iron, and Railroad Co. The mines are situated on the side of Cumberland mountain, 1100 feet above the tracks of the Nashville, Chattanooga, and St. Louis railway. There are three openings in the face of the mountain. The coal is brought by means of tram cars to the head of a double-track incline at the central opening and there dumped into bins. From the bins, the trip cars, carrying five tons each and running in pairs, on both ends of the cable, are filled. The incline is nearly a mile long and is controlled by drums at the top with powerful band-brakes and automatic fan governors. The cable used is the patent interlocked steel wire, 1¼″ diameter. The coal is dumped over a screen at the bottom of the incline, with diamond-top bars arranged in a series of planes, with a fall of 6 inches between the planes. The railroad tracks are built on a grade and cars are moved past the chute by gravity. The use of powder in the mines is largely avoided by undermining in the day and allowing the settling of the roof to loosen the coal during the night. The mines are drained by siphons, so arranged as to be primed by one man without stoppage. So completely has the force of gravity been utilized that there is not a steam boiler on the works. Ventilation is effected by furnaces.

A TEXT-BOOK on mining that has come under the notice of this Department has a diagram illustrating the method of opening a vein-mine, in which, the vein dipping about 45°, the main shaft has been sunk in the footwall, thus increasing the distance to be driven at each successive level. With nothing in the surface trace of the diagram and nothing in the text to explain, this looks like a strange system of mining. Such work, when there is no reason in the slope of the surface to affect the choice of the position of a shaft, is sometimes done; (1) deliberately, where the hanging-wall country is much broken or otherwise bad sinking or standing ground, and (2), more frequently, where the manager has not sufficiently proved the ground to be sure which way the main dip goes.

AN example of well-directed practical work in economic geology is furnished by Bulletin No. 1 of the geological survey of North Carolina, which consists of a preliminary (but quite full) report by Mr. H. B. C. Nitze on the iron-ores of that state. This report is evidently intended to be of use, and gives the sort of information that will be of value to those who are interested in the iron-ores of the region. It begins with a clear explanation of the composition, characteristics, impurities, and commercial value of iron-ores in general, without which explanation the bearing of such a report would not be wholly intelligible to the readers for whom it is intended, and then proceeds to a detailed description of the areas surveyed. The report shows that North Carolina possesses very important, widely-distributed deposits of almost every class of iron-ore, including much of Bessemer grade.

SO many theories have been advanced and disputed as to the origin of petroleum and natural gas (which, it is admitted, must be considered together), that it may be well, for the benefit of those who have not followed the controversy, to quote the generalizations made by Professor Edward Orton, in his "Petroleum and Natural Gas of Kentucky." They summarize what leading experts regard as safe conclusions. There are of course many minor points to be argued over, but the broad theory is thus given:

1. Petroleum is derived from vegetable and animal substances that were deposited in and associated with the forming rocks.

2. Petroleum is not in any sense a product of destructive distillation, but is the result of a peculiar chemical decomposition by which the organic matter passes at once into this or allied products. It is the result of the primary decomposition of organic matter.

3. The organic matter still contained in the rocks can be converted into gas and oil by destructive distillation, but, so far as we know, in no other way. It is not capable of furnishing any new supply of petroleum under normal conditions.

4. Petroleum is, in the main, contemporaneous with the rocks that contain it. It was formed at or about the time that these strata were deposited.

The supervisor of natural gas for the state of Indiana, Mr. E. T. J. Jordan, holds similar views. In his last report he argues that both petroleum and gas have their origin in the organic substances that were imprisoned in the sedimentary rocks at the time of their formation; that they are the products of the decomposition of the animal and vegetable matter deposited in the sand and mud-beds of the ancient oceans under the conditions then prevailing. As these substances were limited in their extent, and in some localities the conditions favorable to the generation and retention of oil and gas did not exist, it logically follows that these products must be limited in extent. Also, that the formation of these products in commercial quantities, if any at all, has ceased many ages ago. Now if this be true, and experience bears Mr. Jordan out in the belief, then we may be sure that the time is fast approaching when the entire quantity will be exhausted. Turn whatever way we may in our exploration and theorizing, these facts stare us in the face. Within all the rich gas- and oil-fields this end has been hastened by reckless extravagance and waste. Mr. Jordan estimates that in the Indiana field alone, during the first years of gas development, 100,000,000 cubic feet of gas were wasted every day, and that, at the low prices ruling, the waste to the present would amount to upwards of $20,000,000. Similar deplorable statements might be added regarding other gas-regions. A few years ago it was calculated that 60,000,000 feet per day were burning from waste-pipes connected with the Pittsburgh supply alone. Latterly there has been a reaction in favor of economy; but it comes rather late.

AMONG methods of concentration not usually cited in the books, and perhaps not known to some of our readers—if ever put into practice by any of them—is one which commands attention because of its simplicity and originality. An old account says: "The natives of Aruba island, one of the Leeward islands in the Caribbean sea, pour the water containing the gold upon the woolly head of one or more of their number, which is a very effectual means of arresting the gold." We have all heard of sheep's pelts (the famous "golden fleece" of mythology) and strakes of cowhide (tanned with the hair on) being used for the same purpose, and from these has been evolved the modern blanket sluice; but the portable native article is probably the father of all similar devices.

THE department of mining engineering of the Pennsylvania State College favors us with the results of a compilation of the reports of the Pennsylvania coal-mine inspectors in regard to accidents during the year 1893. For seven anthracite districts (the new eighth district not reporting), the figures are: coal produced, 44,083,428 tons; employés, 112,917; fatal accidents, 426; accidents not fatal, 1039. The average tonnage per fatality was 105,211, and per casualty, 42,882. The fatalities were 1 in every 270 employed; other accidents, 1 in every 109.

The ten bituminous districts produced 45,322,559 tons; number of employés, 73,410; fatal accidents, 129; accidents not fatal, 323; tonnage per fatality, 351,338; tonnage per casualty, 140,317; number of employés per fatality, 639; number per casualty, 244.

An analysis of these figures brings out some striking conclusions; that is, so far as one year's record indicates. With an almost exactly equal tonnage in anthracite and bituminous coal-mining, it appears that the men employed in the former branch greatly outnumber those in the latter, and that, while a bituminous-coal miner's life is measured by 351,338 tons produced, the anthracite collier's life stands for only 105,211 tons, or less than a third as much when rated according to quantity of coal raised, though there is less discrepancy if the relative value were considered. In both kinds of mining the specified causes of fatal accidents rank in the same order: falls of roof and coal, accidents connected with mine-cars, etc., from gas- and dust-explosions, and from the use of powder. Accidents classed as miscellaneous are irregular in number.

An inventive genius has worked out the details—on paper—of a combined smelting-furnace and steam-generator. He has evidently been struck with the loss of heat in the discharged water of the ordinary water-jacket furnace, used in lead- and copper-smelting, and proposes to utilize it in this way: The two shells of the jacket are strongly stayed together to resist the steam-pressure to be raised. A connection is made with what is called a boiler, but is really a superheater, placed at a higher level than the top of the jacket—and there you have it. Not satisfied with this achievement, it is proposed to feed the jacket with water from a tank in which the molten slag is run and granulated, thus pre-heating it. There are doubtless many possible ways of utilizing the waste heat of smelting stacks, some of which accomplish this in part. But this is not one of them. One evident objection is that the plan nullifies the object and function of the water-jacket itself, and these are far more important than the saving in fuel sought to be secured. An effective water-jacket needs to be well filled with water,—not with part water and part steam,—so that a good circulation and avoidance of over-heating and priming are essentials. Steam is no protection to the inner shell; the moment the water leaves an exposed surface the molten metal would instantly cut through, and in the upper portions the destruction, though slower, would be as certain.

It would no doubt be feasible to use the waste hot water (at or nearly at boiling temperature) in feeding the boilers, if this were done in a reasonable way. The waste heat in the escaping gases from lead-or copper-smelting furnaces could also be utilized to a certain extent, in the sume directions that have been successfully pursued in iron-smelting. There are also some related devices, such as that of setting boilers over reverberatory furnaces, where the direct heat of the furnace is thus utilized. Lately, too, a method of utilizing the heat of slag for generating steam has been introduced in Australia and patented in this country. The plan, which is reported to work profitably (giving 80 horse-power in one case), consists in inserting into Cornish or similar boilers a series of tubes, of slightly inverted conical shape, which pass vertically through the boiler. The slag-pots are emptied into the hoppers of these tubes in succession, and the molten slag communicates its heat through the tubes to the water, generating steam. As the slag cools it slightly contracts, and, owing to the conical shape of the tubes, is readily detached and dumped below. Although so favorably spoken of, the scheme has obvious drawbacks, one of which is the strain put upon the boiler and slag-pipes by intermittent action.

One feature of the recent great coal strikes, involving nearly 150,000 men perhaps, and spreading over twelve states, is that they occurred just at the time when so much complaint was heard about "unemployed labor" and the difficulty or impossibility of getting work, the assumed causes of the agitation culminating in the Coxey crusade. It is the old story. After the panic of 1873 there were similar strikes and "labor troubles" during the following four years, and the same complaint that no work was to be had. It is true that in many localities, and in many branches of industry, there is scarcity of work and much distress; but for this very reason, that coal strikes should occur at such a time would be an anomaly were it not for the strong position of the strikers in view of low stocks and a threatened coal famine.

THE approaching expiration of the patents on the basic-steel process will throw the process open to the world, and it can be used by any one without paying royalty. The *American Manufacturer* states that the process in Great Britain alone has yielded more than £150,000 to the owners of the original patents, the profits, however, having been distributed among a large number of owners. This sum, though large, is not at all disproportionate, in view of the value of the method. As the *American Manufacturer* says, "the history of the basic process for the manufacture of steel, when written, will be of more than passing interest for, if faithfully recorded, it will illustrate the struggles made by those who go forward in the world of metallurgical improvement. It has seldom occurred that a metallurgical innovation has had a harder up-hill struggle against powerful adverse influences."

SOME astonishing claims are made for a new steel-hardening process, in which the article to be hardened is brought to a dark red heat, then dipped into a patented composition called "durol" for ten to twenty seconds, then heated slowly to a cherry red, and cooled directly in tepid water. Drills treated by this process are said to cut through the hardest steel without lubricants and to last much longer than ordinary drills. One naturally looks with suspicion upon any patented process involving the use of a mysterious dope, but this is said to have been in use by the large German steel-works for two years and is now being introduced into England. The nature of the "durol" composition is not stated, but curiosity would be satisfied by a simple chemical analysis.

FOR a long time attempts have been made to perfect an electro-zinking process applicable to steel, especially in the form of plates used for shipbuilding, and it is now reported that the objections of slowness and expense of the operation, and defective coating caused by the retention of part of the acid solution in the zinc and setting up destructive galvanic action, have been overcome. There have been serious drawbacks connected with the old dipping process (miscalled "galvanizing"), among them the waste of zinc in iron-zinc dross and the consumption of fuel required to maintain the large baths of zinc (usually some fifteen to twenty-five tons) in molten condition. It is claimed for the new electro-zinking method that plates eighteen feet long can be coated with ease, certainty, and maximum adhesiveness, that it is much cheaper than hot "galvanizing," and that there is no distortion or warping of small pieces by heat, as in the old method.

KENTUCKY, in 1893, produced 3,246,493 net tons of bituminons coal and 45,539 tons of cannel; the former increasing considerably over the output for 1892, while the yield of cannel has fallen off, owing to the exhaustion of workable seams in certain mines..... The coal output of Missouri has increased 40 per cent. in the last five years. In 1893 it amounted to 3,190,442 tons, an increase of 173,157 tons over 1892, although the number of mines in operation in 1892 was fifty-one less than in the preceding year.

AMONG newly-proposed processes for the extraction of gold from refractory ores is one announced by a London chemist. From the published description it appears to be a combination electrolytic-amalgamation method, embodying also several old ideas. The inventor lays down the following principles as a basis: (1) the circulation of the pulverized ore between negative and positive poles; (2) a solvent liquid for the gold; (3) means of collecting the electrolyzed gold; and (4) the concentration of the positive pole. In this process, which is called the "universal," as it is intended to be applicable to all classes of refractory gold-ores (containing sulphur, arsenic, zinc, etc.), the first requirement is met by having a screw propeller set vertically near the bottom of a tank. The solvent is a dilute solution of potassium cyanide, and the collection of the gold is effected by a bath of mercury, which constitutes the negative pole. The positive pole consists of a mass of powdered pitch or rosin consolidated by heat. The crushed ore, mixed with water, is placed in the tank, with the quicksilver bath at the bottom. The screw circulates the pulp down the center of the tank, impinging upon the surface of the quicksilver, and traveling up at the sides (on which the positive pole is laid), and back down the center, and so on, the idea being to give it every opportunity for intimate contact with the "quick." This screw device has often been tried, but generally to drive the pulp through, and not merely over, the surface of the "quick." At the same time, the electro-chemical action is intended to keep the mercury active and bright, not allowing it to become sluggish—a plan followed in the Wiswell and other methods. The chief advantages claimed for the process are that the gold is extracted directly from the ore without any other preliminary treatment than crushing; that the same chemicals are used over and over again—which cannot be wholly true, since there must be a constant loss of the cyanide solution and mercury (which involves also a loss of amalgam) in the spent pulp; that the process efficiently extracts the gold and silver from the auriferous ores, whether refractory or free; that the precious metals are obtained at once from the amalgam in the metallic state without further chemical treatment, and that any workable quantity of ore may be treated in one vessel at one operation, and the gold obtained in one day. Such a process would undoubtedly work, though probably not up to the degree of extraction claimed (over 90 per cent. in some cases); yet it is not easy to see how it should have any advantage over either of the simple cyanide leaching processes, with precipitation on zinc. But wherever there are means of cheap transportation to a silver-lead smelting establishment, the ore, if it carries a heavy percentage of base sulphurets, is best concentrated at or near the mine and shipped to a smelter, where practically all the gold (or at least nearly up to the fire-assay showing) and about 95 per cent. of the silver can be saved. It is true that a subsequent refining is necessary to get the gold and silver out of the base bullion, yet the closeness of extraction offsets this. Or if the sulphurets are low, an amalgamation-concentration process (the one commonly employed) or a concentration-amalgamation process (the two stages being reversed) would answer, the concentrates in either case being subsequently smelted or leached. There may be room for a new method, to meet local requirements, especially where there are no cheap shipping facilities, but the metallurgist has already choice of several standard and proved methods to cover almost all conditions. It is a great mistake to suppose that refractory gold-ores are any longer to be considered a bugbear. Almost anything can be concentrated and smelted, and for heavy, base gold-ores the pyritic-smelting method is available. The new scheme evidently has the drawbacks of intermittent charges, loss of mercury and amalgam by mechanical entanglement in the pulp, cost of an expensive chemical (cyanide solution) acting merely an auxiliary part, etc. Like the other mercury-bath and lead-bath plans it has theoretical claims which are hard to substantiate in practice.

CIVIL ENGINEERING

Conducted by John C. Trautwine, Jr.

THE selection of Niagara Falls as the place for holding the annual convention of the American Society of Civil Engineers during this month is a very happy one, not only because of the great works which have been and which are being inaugurated at that place and which must form an object of absorbing interest to the visitors, but also because of the proximity of the Falls to what may be called the center of gravity of the membership of the Society. By far the larger portion of the membership of the Society is located in the Eastern and Middle States, and notably in the State of New York, so that the selection of the Falls must reduce to a minimum the traveling required of the membership as a whole, a point by no means to be neglected in these days of business depression, if a large attendance is desired.

WHEN we consider that less than half a century has elapsed since the formation of the American Society of Civil Engineers and scarcely a quarter of a century since it began to emerge from a condition bordering on oblivion, when we consider too that there are now at least four strong and fully-organized national engineering societies in the field, with a host of allied institutions, such as those of master car-builders, locomotive engineers, etc., we can form some idea of the tendency of these recent times, toward coöperation of this sort. Coincident with the development of these national societies has been the creation and steady growth of innumerable local and sectional engineering and technical societies. So long as the national societies fail to make provision for the formation of sections in parts of the country more or less remote from the headquarters, a matter which it seems difficult to arrange satisfactorily, so long the national and local societies will have a reason for their existence.

And a measure of coöperation is obtained also among these local and sectional societies. A dozen years ago there was formed the Association of Engineering Societies, consisting, at that time, of the four societies of Boston, Chicago (Western Society of Engineers), Cleveland and St. Louis, and organized for the purpose of securing joint publication of the papers and proceedings of those societies. Since that time the Association has issued twelve annual volumes of its monthly *Journal*, and it now embraces five societies in addition to the original four. The *Journal* has grown until it has now a matter of some 750 pages annually. The Association offers a means of publication to societies so small that it would be practically out of the question for them to maintain separately a regular publication, while even the largest of the societies concerned secure, by this means, a better presentation of their papers than could be secured at anything like the same cost if they were to attempt it separately, to say nothing of the advantage of having spread before them the transactions of the other eight societies. An incidental advantage of this form of coöperation is seen in the fact that a number of the societies comprised within the Association have adopted a provision for the exchange of members with each other.

AT the May meeting of the Engineers' Club of St. Louis, one of the largest societies embraced within the Association, Past-President Robert Moore read a paper on the "Filtration of City Water Supply in the Light of Recent Researches." In the matter of filtration of public water-supplies, our European brethren have made far greater progress than we, possibly because the natural supply there is so limited, relatively to the populatition making a demand upon it and contributing to its defilement, that filtration is more urgently and obviously necessary there than here. Mr. Moore referred to the investigations of Mr. Kirkwood on behalf of the city of St. Louis, in 1866, in the course of which he visited many foreign cities. It has long been a mooted question whether sand-filtration removes the germs of disease. It has been claimed that such filtration retains merely the solid particles held in suspension, and that it even tended to the increase of disease-germs; but it has now been shown that these fears were groundless, and that sand filtration is an effective protection against the carrying of such germs into the distribution. Mr. Moore estimated the cost of the filter system for the city of St. Louis at $2,000,000, and the annual expense of operation, maintenance, and interest charges, at $150,000. In the discussion it was stated that the water department was preparing plans and conducting experiments with different systems, and would be ready to act as soon as the funds were available.

SINCE the inauguration and successful establishment and conduct of the World's Fair, the country instinctively looks to Chicago for the inception of grand ideas. It is therefore perhaps not surprising that from the Western Society of Engineers should come a suggestion for the formation of an International Institute of Engineers. It is eminently fitting that such a proposition should have originated with a man of international reputation, like Mr. E. L. Corthell, and it is greatly to be hoped, not only for the interest of the engineering profession but for that of humanity at large, that some such proposition should be carried into effect, for it wants but a sufficient number of object-lessons of this kind to accustom the popular mind to the advantages of international coöperation, and the gradual obliteration of international boundaries.

Turning from this matter of cosmopolitan to one of local interest, but of similar import, we are glad to note that steps are being taken looking to the formation of an engineering society in Rochester, N. Y. The tidings come to us in a letter from Mr. Robert Cartwright, who evidently recognizes the difficulty of distinguishing between the civil and the mechanical engineer, since his letter-headings bear the simple imprint "Engineer," and who seems to be the prime factor in the movement, a circumstance which, to those who know something of Mr. Cartwright's energy and ability, will augur hopefully for the prosperity of the new organization.

MR. M. J. MURPHY, street commissioner of St. Louis, Mo., has issued a circular letter asking for the expression of opinions as to the feasibility of holding a national convention of the members of boards of public works, with a view to the interchange of ideas and of information respecting municipial government and municipal works. Such a convention could hardly fail to do a great and good work in the way of increasing and broadening our knowledge in such matters, and it is greatly to be hoped that it may become an accomplished fact.

AT the Hague, in July next, will meet the Sixth International Congress on Internal Navigation. Among the subjects to be considered are the construction of navigable canals designed for operation at high speed, methods of traction and propulsion upon canals and rivers, and the regulation of rivers at low water. It is desired to awaken in America increased interest in these congresses, and Mr. F. Collingwood, the Secretary of the American Society of Civil Engineers, No. 127 East Twenty-third street, New York, will transmit the applications or remittances of those desiring to attend the congress or to receive its publications. The cost of membership is only $5 annually, for the congresses receive financial aid from the governments of the countries in which they are held. A number of excursions will be made from the Hague to points of interest in Holland.

Mr. Edward P. North, whose address is at the house of the Civil Engineers, as above, tells us that the proceedings of the congress will be printed in English, provided at least two hundred subscribers can be obtained in this country at five dollars each. Even in these times there should be no difficulty in raising this quota.

PERHAPS no engineering works give rise to more complicated problems touching the respective rights of individuals, corporations, and communities, than those connected with the flow of streams, whether those be utilized as sources of water-supply or as means for the removal of sewage. Some difficulty of this sort has naturally been encountered in connection with the great drainage channel by which Chicago proposes to reverse the current of her dirty river and let the waters of Lake Michigan flow backward through it across the divide, and, eventually, into the waters of the Mississippi. Not unnaturally, the communities along the route of this proposed stream are exercising themselves over the possible consequences of such a visitation.

Advices just received from Signor Pasquale Sasso, a noted Neapolitan engineer, give an account of a proposed work in that neighborhood, in which it is proposed to carry the waters of certain streams through the Apennines in order to supply the countries lying upon the other side. The town of Benevento, with some 21,000 inhabitants, lying thirty-five miles northeast of Naples, is situated on a hill, at the foot of which two streams—the Sabato and the Calore—flowing from the southwest slope of the Apennines, unite their waters on their way to the Mediterranean. The old town was called *Male*ventum until it became a Roman colony in 268 B. C. It stood on the Appian way and boasted of a triumphal arch to the emperor Trajan, and the arch is still standing. It was furnished with water by means of an aqueduct about fifteen miles long, and carrying over 86,000 cubic meters daily. At the foot of the opposite, or northeast slope of the Apennines, stretches the sparsely populated plateau of the Puglia, devoted chiefly to grazing; and, in order to supply this territory with water, various schemes have been on foot for thirty years or more, for tapping the sources of some of the streams of the southwestern slope, among others those of the Calore. But Signor Sasso, in his pamphlet, calls attention to the injury which would thereby be wrought upon the inhabitants of Benevento and of the surrounding district, and of the advantages they could gain by diverting these waters to their own use. The head waters of these streams are found at an elevation of about 1500 feet above the sea, and they furnish, at their minimum flow, over 500,000 cubic meters daily. The qualities of the water are practically the same as those which formerly flowed through the ancient aqueduct of which we have spoken, and which now are diverted for the uses of Naples. Signor Sasso sketches briefly an ambitious scheme by which a considerable portion of this water could be utilized, at a cost of some $5,000,000, to supply a large tract of country, including the town of Benevento, and supporting a population of about 167,000 inhabitants; but, in view of the difficulty of securing so large a sum, he devotes himself chiefly to elaborating a more modest project, costing some three hundred thousand dollars, and supplying simply the town of Benevento and the country lying along the route of the aqueduct. The latter would be about twenty miles long, with a cross-section of 0.5 × 0.5 m., covered with a semi-cylindrical roof, and would have a slope of 1 in 1000. Such an aqueduct, by Darcy and Bazin's formula, would have a velocity of nearly 1 meter per second and would carry the 230 liters required for the purpose.

WHEN we remember the violent opposition to the introduction of the trolley system, which scarcely a couple of years ago manifested itself in Philadelphia as in other cities, and which found vent in overflowing mass-meetings and in vehement protests from the local press; and when we contrast this with the present condition of affairs as respects the construction of trolley lines, and with the evident favor which the new system finds in the eyes of the populace, we are irresistibly reminded of the transition in the feeling of the mob in "Julius Cæsar" under the speeches of Brutus and Mark Antony. In this case, however, Antony, as personified by the traction company, after allowing Brutus to exhaust his efforts upon the audience, instead of retaliating in like kind, quietly secured permission to construct its first line in an out-of-the-way district, and trusted to this object-lesson to make speeches for it. The result has proved the wisdom of this course, for now when trolley speaks no dog barks.

Not the least of the benefits conferred by the introduction of the trolley system is the incidental one of the long and sadly needed improvement of the street-paving of the city. The passenger-railway companies, in consideration of the privilege of constructing and using their trolley systems, are required to pave the streets from curb to curb with improved paving. In many cases this is of asphalt and in others of granite blocks, and it begins to look as if Philadelphia, so long conspicuously deficient in this respect, would shortly become one of the well-paved cities of the world, were it not for the fact that, according to the local press, the specifications are so worded as to give a monopoly of the work to a single firm, with the result that fears are entertained that a further expense will be entailed by the necessity for the erection of awnings to preserve the new pavements from the ruinous effects of the showers of spring and the suns of summer.

Broad street, which may be regarded as the backbone of the city, and which extends in a straight line from League island at the south, for a length of over seven miles to the northern city limit, a line unbroken except by the great City Hall at the intersection of Market street, is now asphalted over the greater portion of its length.

UNTIL recent years the street-car and the city passenger railway have occupied a very modest position in the world of engineering, and have enlisted scarcely a fraction of the attention which has been devoted to the pressing and large-scale problems of transportation between distant centers of population. One of the most remarkable signs of the times, however, is the revolution which has taken place in this respect, a revolution which owes its existence largely to that great discovery of Siemens which permitted the application of electricity to the transmission of power upon a large and practical scale. To-day the subject of intramural transportation is rivaling that of steam railroading in importance and in the attention bestowed upon it, and even bids fair at no very distant date to become the more important branch of the two. Scarcely a decade has passed since the time when the occasional reports of electrical railways in operation in more or less obscure towns in various and generally remote parts of the world were received with something approaching incredulity, and were of course met with the usual prediction that such innovations would never work in practice. To-day finds almost every little town the center of a great and rapidly growing system of radial lines connecting it with its more or less distant neighbors, and it seems almost certain that the next ten years will find at least the more densely populated sections of our country covered with a complete net-work of these lines.

AMONG the interesting early drawings left by the elder Trautwine is one which he prepared when about eighteen years of age, by direction of his employer, the late William Strickland, for the edification of Jesse Hartley, Esq., of Liverpool, who was at that time visiting this country in search of information for his guidance in the improvement of the port of Liverpool. The drawing, which formed a part of the exhibit of the Pennsylvania railroad at the World's Fair in Chicago, represents one of the old ferry-boats moved by horses, which then plied across the Delaware river between the cities of Philadelphia and Camden. The horses walked continuously on a horizontal tread-mill placed amidship of the boat, and the power thus generated was transmitted by means of beveled gearing to the paddle-wheels. Trautwine and one of his companions in Mr. Strickland's office were detailed to inspect and measure the boat and to prepare the drawing from the measurements thus obtained.

Early in 1851 the same engineer designed a suspension bridge, with four spans of 1000 feet each and two of 500 feet each, to cross the Delaware river at the same point, and since then numerous designs have been offered for this purpose, but the passage of the river is still effected by steam ferry-boats, the successors of the antiquated *team*-boat depicted in the drawing referred to. The lowest bridge on the stream is that of the Pennsylvania railroad at Trenton, 30 miles further up, at which point is the head of tide-water. Now, however, it begins to appear that the river at this point may some day be spanned by a bridge. A bill has been introduced in congress authorizing a company to construct the bridge, provided the assent of the states of New Jersey and Pennsylvania shall be first obtained, the plans of course to be subject to the approval of the secretary of war. When completed, the bridge will be a post-road, over which the United States mails shall at all times pass free.

THE new bridge, however, is not to be the long desired highway bridge joining the cities of Philadelphia and Camden, and crossing the Delaware at Market street, but primarily a railroad bridge, designed, evidently, to connect the Pennsylvania railroad system on the right or Pennsylvania side of the Delaware with its very important system in the southern portion of New Jersey, which connects Philadelphia with the innumerable seaside resorts lining the shore of that state. Only incidentally and permissibly is provision made in the bill for the adaptation of the bridge to highway purposes; and the fact that its location is to be several miles above the crossing referred to renders even this provision of no great account; for very little, if any, traffic would go so far up-stream in order to avoid the short trip across the river by ferry. The bridge is to have a channel span of 500 feet, with a clear head-way of 40 feet and a draw span of 125 feet clear each side of the pier.

Philadelphia has long felt the need of a better highway to the sea than that provided by the long and tortuous channel of the Delaware river, and now, notwithstanding the government has done much to improve that channel, the citizens seem to be thoroughly aroused to the importance of the construction of a ship canal to provide the necessary outlet. A public meeting was recently called by the mayor at the request of leading firms and citizens, and that official appointed a canal commission, composed of eleven prominent men. Members of this commission, accompanied by representative citizens of towns lying upon the proposed route of the canal, have since gone over the route, which will ascend the Delaware river to Bordentown, a short distance below Trenton, N. J. From this point the route will follow, more or less closely, the bed of the existing Delaware and Raritan canal, which will be widened for the purpose, but the rectifications proposed in the course of this canal will shorten its length from forty-four to about thirty-four miles. There will be a tidal lock at each end of the proposed ship-canal, and two locks at each end of the summit level, which will be about twenty-two miles long and fifty feet above the sea-level. It will be seen that this project resembles that of the Manchester ship-canal in this, that in each case the canal is a means by which an inland town reaches out to the harbor of a prosperous rival which has hitherto enjoyed the lion's share, if not the whole, of the shipping which it is now sought to divide. Professor Lewis M. Haupt, who from the first has taken a warm interest in the project, recently pointed out, in the *Journal of the Franklin Institute*, in an article entitled "The Manchester Ship-Canal and its Lesson," the parallelism between the two cases.

THE Iglawa viaduct, near Kanitz-Eibenschitz, in Moravia, on the railway line joining Vienna and Brunn, was built in 1868–70 by F. Cail & Co. and the works at Fives–Lille. It has six spans of about 200 feet each, and the rails are about 140 feet above the waters of the Iglawa. It is a single-track viaduct, with continuous trusses about 18 feet deep, having parallel upper and lower chords. These were supported on five cast-iron piers, each of which consisted of four tubes filled with concrete. The entire cost of the structure was about $350,000. Owing to the unequal contraction of the iron and the concrete, serious defects began to exhibit themselves soon after the erection of the bridge. Longitudinal cracks appeared in the cast-iron tubes, and it is said that it literally rained rivets and bolts upon the site of the bridge. This naturally gave rise to lively apprehension on the part of the traveling public, and to corresponding anxiety on the part of the railway officials. It was proposed at one time to replace the viaduct with one of stone, but this idea was abandoned, and it was determined instead to replace the old cast-iron piers with new ones of wrought-iron, and this work has been carried out without interruption to the passage of the thirty-six daily trains.

The old pier-legs were utilized for the erection of their successors without the necessity of constructing special false works, and, after the erection of the new piers, these in turn served for the removal of the old. The quadrangle formed by the four new legs of each pier is placed just within that of the four old ones. After the piers were in place, the maximum interval of three hours between trains was utilized for the jacking up of the trusses and for lowering them upon their new supports. This was accomplished by means of hydraulic presses. One of these presses burst just as it had lifted its burden to the maximum height, but the precaution had been taken of inserting piles of iron plates under the lower chords of the trusses as they rose, and thus, although the truss had been raised some 40 inches, it fell but one or two millimeters.

As first constructed, both ends of the continuous truss were left movable, with the design, however, of fixing the end nearest Brunn. It therefore became necessary, after all was in place, to move the entire superstructure close up to the face of the abutment at the Brunn end, previous to fixing it there, so as to allow the space of 60 millimeters (about two inches) required at the Vienna end to allow for expansion. The moving of the superstructure was effected by means of its own expansion and contraction under changes of temperature, wedges being placed alternately at the two ends in such a way that the expansion of the truss during the day and its contraction during the night should cause it to creep, caterpillar-like, into the desired position. Owing to the fact that this operation was performed at a season when the diurnal changes of temperature were of but slight range, the operation required several days.

In describing the new Tower bridge at London, in THE ENGINEERING MAGAZINE for April, we took occasion to refer briefly to a number of remarkable devices which had been submitted for crossing the Thames at that point without forming a permanent obstruction to the navigation of the river. Among these was the design of Sir G. Barclay Bruce for a rolling platform which was to move across the river upon the tops of piers so placed that the platform should at all times rest upon at least two of them. Somewhat similar to this in fundamental principle, and yet widely different from it in its application, is the bridge of 160 meters span, designed by the engineers de Palacio and Arnodin, and recently erected over the River Nervion, in Spain, between Portugalete and Las Arenas. In this case a tall pier is erected on each side of the stream, and the two are connected near their tops by a horizontal platform. Thus far the structure is in fact a suspension bridge, with main cables and back-stays, but the elevated floor joining the two piers has no direct connection with the ground. From it, however, is suspended a traveling platform, elevated only so far above the water as to be beyond the reach of the highest waves. This traveling platform is capable of conveying railway-carriages and other vehicles, and can transport 150 persons across the stream in one minute. The fixed elevated platform, from which the traveling platform is suspended, is placed at such a height that tall vessels can readily pass underneath it.

OWING, no doubt, to the dangers, real or imaginary, attributed to the trolley and its wire, the new system seems to have found its most striking development in and about the smaller towns, where population is comparatively sparse, and has been looked upon askance by the larger cities, where danger to life through shock and to property through fire, is more seriously imminent.

Boston, it is true, has for some time rejoiced in, or suffered from, an extensive system of trolley lines, but their development has scarcely begun in New York or Chicago, although we note that ordinances permitting their construction have been enacted in the latter city. Philadelphia, despite its proverbial conservatism, seems to be following next in the lead of Boston, so far as the large cities are concerned. Several years ago a storage-battery line on Lehigh avenue in the northern portion of the city was put in operation, but the batteries were soon abandoned, and horse-power reverted to. For more than a year, however, the Philadelphia Traction Co. has had in operation a line crossing the city from east to west on Bainbridge and Catherine streets, in the southern section, and within a year it has added parallel lines on Morris and Tasker streets, still further south, while the last few months have witnessed the construction and eminently successful inauguration of the company's north and south lines on Thirteenth and Fifteenth, Twelfth and Sixteenth streets. Indeed, a stranger visiting the city during the latter half of 1893 might have imagined that the entire street system of the city was undergoing an upheaval, for it seemed as though the majority of the streets were rendered impassable by the preparations for the trolley lines; and now the chief of the electrical bureau is credited with the statement that every street-railway line in the city has applied for and obtained the privilege of constructing a trolley system. Among the lines where the work of reconstruction is now in progress, are the Hestonville, Mantua, and Fairmount, running chiefly upon Arch, Race, and Vine streets, of which Mr. A. Langstaff Johnston is in charge, and the Frankfort and Southwark, or Fifth and Sixth streets line, which began life, as the first street-car line in the city, during the early childhood of the writer.

It seems much to be regretted that it has not been found advisable in Philadelphia to use the grooved rail, which renders travel for vehicles crossing the tracks so much safer and more comfortable. The chief objection to that form of rail seems to be its liability to pack with ice in cold weather.

WITH the phenomenal growth of intramural and suburban systems of transportation, the question of their control and ownership becomes a burning one. If it is important that cities should control their supplies of water and of gas and their sewerage systems, in order that a harmonious system may be obtained in place of a series of warring interests, it would seem no less desirable that the town should control the means of transportation by which its citizens reach its various portions and the outlying districts. The New York board of trade, we notice, has approved the plan of Mr. Abram S. Hewitt by which the title of the proposed rapid-transit system for that city is to be placed in the city itself. The operation of the system, however, is to remain in the hands of a corporation, the choice of the corporation to be determined by the annual rental which it will bid to pay. The construction of the system, according to Mr. Hewitt's plan, will be superintended by a board of engineers appointed by the city, who will also see that proper accommodations are provided for the public.

This rapid extension of the trolley system, so greatly facilitating intercourse with the suburban districts, must in a short time revolutionize many of our habits of city and country life, greatly relieving the pressure of population in the cities themselves and enabling their inhabitants to find homes under far better hygienic conditions.

MECHANICAL ENGINEERING

Conducted by Henry Harrison Suplee.

IN a paragraph in this Department in a preceding issue attention was called to the fact that much information may often be gained regarding engineering problems by assuming the members of a structure to be replaced by the observer himself, and thus reasoning out the problem, so to speak, by an *argumentum ad hominum* not perhaps exactly of the kind intended by the earlier logicians. This idea is by no means limited to the investigation of statical problems, but may be applied to many other subjects with results which are at least interesting and may possibly become valuable. The writer well remembers how, a number of years ago, he climbed upon a pedestal in order to escape the pressure of a surging crowd, and how, from this vantage point of observation, he could see the action of a fluid, the molecules of which were composed of human beings alleged to possess at least a certain amount of free-will in the control of their actions. A disturbance at one point caused those in the immediate neighborhood to jostle each other and the resulting motion could clearly be seen to pass over the whole multitude in constantly widening circles of waves, identical in appearance with those produced when a pebble is cast into a pool. Each individual acted as if he thought he were pushing and crowding on his own independent, individual account, while, in reality, the whole mass was moving in absolute accordance with the mathematical laws of fluid motion. In like manner the "throttling" of a crowd passing through a narrow entrance-gate is not unlike the impeded flow of steam through inadequate ports and passages.

The fact that a cannon-ball fired horizontally will reach the ground simultaneously with one dropped at the same instant from the same height may not be self-evident to every one, but if the idea be illustrated by a ball dropped from one's hand while riding in an express train at full speed, it will at once be seen that the time of falling must be identical with that case in which there is no horizontal motion.

The real value of such methods lies in their availability to simplify conceptions of problems which may be presented in unnecessarily complex forms, and thus enable the actual and controlling conditions to be grasped immediately, leaving more accurate determinations to be made thereafter.

THE speeds which have been made by the various cruisers of the United States navy, usually based on a four-hours' run under the most favorable conditions, may be compared in an instructive manner with the average speed of the Cunard liners, *Campania* and *Lucania*, during the year's steaming, just concluded. The *Campania*, being the first completed of the two steamers, has rendered the greater amount of service, having traversed about 50,000 nautical miles, at a mean speed of 20.304 knots per hour, while the *Lucania* has made practically the same speed, it being 20.394 knots average speed, for over 33,500 nautical miles. When it is considered that these speeds have been maintained under continuous commercial conditions of actual service intended to inure to the benefit of the steamship company, rather than to gain a premium for the builder one is tempted to ask how many of our new cruisers could maintain anything like such a continuous rate of speed as 20 knots for six consecutive days without a hot bearing, leaky boiler, or mishap to any important auxiliary! It must also be remembered that this record includes all the retarding influences of adverse weather throughout the year, in a season which has had rather more than the average share of heavy weather such as would be considered entirely unfit for any possible trial run under any circumstances.

MUCH has been written upon the subject of mechanical drawing, and there are many admirable text-books upon this important branch of technical education. Nearly, if not quite, all the treatises, however, consider the drawing entirely with regard to its first and principal purpose,—that of serving as a means of conveying the ideas of the designer to the constructor who is to execute the work,—and do not give enough attention to the secondary, but still important, service of a drawing as a record for future consultation. Nearly every draftsman and engineer knows how often he has to get out his old drawings for reference and comparison, and, when he has thus to work them over, he finds many things which might have been done in a more convenient manner for use, had he only considered them in the first place. When a man is endeavoring to produce a new design he should be able to concentrate his mind upon the immediate subject as much as possible, and the fewer distracting conditions he has about him the better he can work, and among the petty annoyances which disturb the train of thought a few may be worth enumerating.

In the first place, there is no earthly reason for the continuance of the time-honored practice of writing the dimension figures along the direction of the dimension lines to which they belong, thus necessitating the twisting of one's neck or the shifting of a large sheet every time a vertical dimension is to be consulted. The rule of writing all dimension figures on the horizontal line is not only easier in the first place, but immensely more convenient for every one who has to use the sheet thereafter. This method of figuring also improves the general appearance of the drawing to an extent which can only be appreciated by comparison with sheets figured after the old method, and, if introduced by a few leading establishments could scarcely fail to become as general in the United States as it has on the European continent.

The disposition of figures is also a matter which should be considered from the standpoint of the user rather than that of the draftsman, as he may discover when, in turn, he becomes the user himself. The best of all rules in this respect is the altruistic one of "put yourself in his place," which, indeed, applies to many other things, mechanical and non-mechanical as well. The general abolition of the so-called "shade-lines" is a gain, so far as practical use is concerned, which none can deny, and yet, not so many years ago, this was a matter which many draftsmen regarded as rank heresy. After all, the idea of "common sense applied to the use of materials" covers this subject as well as many others, even when the materials consist only of paper, pencil, and—brains.

THE subject of coil boilers, which was briefly discussed in this Department last month, was the basis of a paper presented at one of the informal meetings of the Mechanical Engineers, by Passed Assistant Engineer W. W. McFarland, U. S. N., and the discussion which followed was chiefly interesting in that it showed that a certain undefinable timidity was really all that kept many from endorsing the use of coil boilers in many places where their use is yet withheld.

Mr. McFarland's paper was mainly confined to data from experience with coil boilers in the United States navy, and especially with the performance of the Thornycroft boilers on the *Cushing* and the Ward boilers on the *Monterey*. To use Mr. McFarland's exact words, upon an important point, "the experiments on the Ward and Cowles boilers in competition, and those on the Thornycroft boilers of the *Cushing* and the Ward boilers on the *Monterey*, show conclusively that coil boilers will stand any amount of forcing without injury, as these were all subjected to air-pressures of two inches and over for long periods without a single leak being developed. We fancy that there are few shell boilers of which this could truthfully be said, and it must be remembered that the boilers of the *Cushing* have been in use at least five years, so that, in that instance at least, the experience is beyond the experimental stage. If multiple expansion is to be carried advantageously beyond three subdivisions—in other words, if we are to reap the possible advantages which may reasonably be expected to be obtained from quadruple- and quintuple-expansion engines—we must certainly look to some form of coil boiler to obtain with safety the steam-pressures which such expansions demand. The experience of the members of the American Society of Mechanical Engineers seems to be limited to boilers for launches and similar small craft, and hence no one had any contributions of practical experience of the magnitude which was given in the paper. It seems as if thorough tests on land under continuous and trying service should be the next thing in order, and the promise which is held out certainly makes such tests worthy of serious consideration.

It has been quite common of late to present economical or scientific subjects under the guise of accounts of events taking place at some future date, and the attractiveness of such methods, to both writers and readers, has caused many such tales to be published. The most recent of these is a leading article in one of the prominent literary monthlies, professing to narrate a naval engagement between two modern battle-ships, in a war dated only a few years ahead, and so presumably before present appliances have become obsolete. Notwithstanding the fact that the modern battle-ship is essentially what Captain Ericsson called a "fighting-machine," it might be supposed from the article in question that battles in the near future would be fought much in the same way as that between the *Kearsarge* and *Alabama*, for instance, and that heavier armament and greater destructiveness were about the only advances (?) which had been made in recent years.

It is most instructive to turn to a series of articles which appeared a few years ago in *Engineering*, entitled, "The Story of the Battle of Port Said." This decidedly sharp criticism of the state of affairs in the British navy at that time was far more instructive and valuable, and more entertaining, than any melodramatic effusion describing a theatrical naval engagement could possibly have been, and the manner in which it revealed defects in equipment and operation, as well as the occurrence of "the unexpected, which always happens," make it worth re-reading and applying to matters nearer home. Vessels which had made phenomenal speeds on trial-runs showed distress in remarkably short runs at moderate speeds, and the confusion which existed on some of the battle-ships, after certain men who alone knew and understood the manipulation of the special hydraulic apparatus and other devices had been killed, sets one wondering what would become of some of our numerous electrical devices in an engagements should the specialists become disabled early in the fight! These and other interesting points, for details of which we must refer those who may be interested to the original articles, were supposed to be made the subjects of a special court of inquiry after the battle, and the investigations were quite "official." In the story of our contemporary, however, none of these things happen, and we must congratulate the writer upon the wonderful completeness with which everything mechanical on his vessel must have performed, and return thanks that our ships are not as those of other nations in this respect.

It is interesting to note that the manner in which the broken shaft of the *Umbria* was repaired at sea has given rise to consideration of portable flange couplings to be carried among the "spare" stores for such emergencies. A three-part flange-coupling which can be placed between the thrust-collars of a propeller-shaft and bolted to a similar coupling-flange between the next pair of collars is the subject of a recent British patent, and if all the various places in which a shaft might break could have similar consideration and anticipation such repairs at sea might be more easily and safely effected. It is probable, however, that the shaft would always break at the point for which no especial coupling was carried, owing to the well-known "total depravity of inanimate things."

THE increasing popularity of graphical methods of calculation, as compared with the more precise (but not necessarily more accurate) analytical methods, suggests some thoughts which may not be out of place in this Department, bearing, as they do, upon problems directly relating to the daily work of the mechanical engineer.

The great attraction of graphical methods lies in the directness with which the result is attained and the fact that the whole work is before the observer in a shape to be grasped as a unit, instead of a succession of statements. Every one who has used tables and curve-diagrams to express the same set of relations,—such, for instance, as a set of Regnault's steam tables compared with a curve of steam-pressures and volumes,—will appreciate this fact. Even the simple exercise of graphical addition, marking off the successive items on a strip of paper and then measuring the total length, is in fact doing what is considered quite a feat by the expert arithmetician, as it permits items of several columns in width, as well as fractional quantities of all denominations to be added simultaneously, without previous reduction.

The clumsy notation of the ancient Greeks and Romans compelled them to direct their mathematical ingenuity almost entirely to the solution of geometrical problems, and any one who has seen even a simple example in elementary arithmetic worked out in the Roman system of numerals can imagine how the veriest schoolboy of to-day would appear as a mathematical prodigy merely because of the fact that he possessed the infinitely superior notation possible with the Indian (miscalled Arabic) numerals. When we consider, however, how many unnecessary details of reduction and similar manipulation are avoided by the most elementary graphical processes, the reflection that we are entirely too well satisfied with our present system forces itself upon us. May it not be possible that as great an improvement upon the Indian system as that was over the Roman is possible, and that, while the solution by graphical methods is only an indication of what may be attainable, yet the indication may be clear and the solution not far off?

There are some analogies in our present system which point in the same direction,—notably the curious properties of the figures nine and seven; and the manner in which such arithmetical prodigies as Mondeux, Colburn, Bidder, and Inaudi operated makes one regret that the processes by which they performed calculations mentally which required much longer time for "experts" to accomplish with pencil and paper, were not investigated, at least to an extent which would give a clue to the conscious or unconscious process employed. The direct methods of nature go immediately to the results which they must produce, just as a freely suspended chain forms a catenary without requiring any guidance, and it may not be too much to hope that some day we shall be able to think and calculate by methods as direct as the action of the forces which we are endeavoring to grasp.

THE question of the relative economy of a main central engine against several separate motors is one which cannot be decided broadly, as the conditions of transmission and similar subjects vary in different locations to such an extent that each case must be decided on its own merits. It seems, however, in many instances that the loss of power in transmission forms far too great a proportion of the total to warrant the concentration of power in a single engine in large establishments, especially when the various buildings to which the power is transmitted have been added from time to time, and placed with regard to other conditions than those of economical transmission of power.

When it is considered that in very many instances more than half the power of a large plant is absorbed simply in getting the other half to the place where it is to be used, it certainly appears as if there was room for improvement, and, although some concentrated establishments keep the "friction" load down as low as 40 per cent., yet there are more in which it exceeds 50, and some where it is greater than two-thirds of the total power developed by the engine. We have heard the missionary society sneered at because it required two dollars of expenditure in administration for every dollar which it transmitted to the heathen, but it is to be hoped that the sneering was not done by a mechanical engineer, or at least that the vitreous nature of his residence was not perceived by the party under criticism. Just how this loss in transmission is divided can hardly be determined, but from the proportionally low specific transmitting capacity of shafting as compared with belting or with rope transmission it seems as if the greater portion of the loss was due to the long lines of shafting with which every manufacturing establishment is filled. A central steam-generating plant with a moderate number of engines, placed with especial care to avoid complications in transmission, together with a judicious use of high-speed rope transmission, would seem to offer the most feasible means of keeping down the transmission losses to a minimum, and when this is supplemented by electrical transmission to the tools, so as to obtain the great advantage of a transmitting medium, the resistance of which ceases when the tool is not in use, we shall no longer hear of engines with a friction load of more than half the entire power which they develop.

In a recent issue of this Magazine reference was made to the mechanical engineering problems which had been more or less imperfectly met in the important subject of safe- and vault-construction. There is a new element which may enter into this subject and make the task of protection against burglars more difficult than ever. The present methods of protection assume that, if a vault is strong enough to require more than a few hours' work with hand-drills to penetrate it, it is safe against attack during the time it is left alone for a single night. It may not be impracticable, however, for the burglar to come provided with a light electric drill and a cell or two of storage battery in his kit, and with such weapons at his command he might soon pierce a small hole, inject the liquid explosive and be off before he could otherwise have made any impression upon the vault. While this has not as yet been attempted, it is not always wise to allow one's self to be taught by the somewhat expensive tuition of a burglary, and it should be within the province of the engineer to guard against such a possible method of attack.

The old idea of reversing the motion of an engine by shifting a single eccentric directly across the shaft has been revived in a new form by Mr. David Joy, the well-known inventor of the Joy valve-gear. Mr. Joy's design does not differ in principle from the old wedge-motion of Dodd, except that the eccentric is shifted by means of hydraulic cylinders and plungers operated by a solid rod of oil communicating through the center of the shaft and controlled directly in the case of a locomotive engine, from the cab of the engine-driver. That there may be difficulties to be overcome in the matter of leakage is doubtless true, but at the same time the directness of the construction appeals very strongly to the engineer who has a due regard for the importance of simplification in all possible details. The action of a liquid rod and the solidity of such connections is sometimes brought most forcibly to one's attention when a bad case of water-hammer occurs in a large steam-pipe connection, and the persistence with which the apparently solid liquid refuses to escape through the most invitingly prepared openings makes it interesting to observe the success which may attend this effort to utilize this most annoying enemy. A few ounces of water in a cylinder will knock the head out as promptly as if a monkey-wrench had been carelessly left inside, and, in fact, there is less evidence of compression to be observed in most liquids than in many of the solid materials of construction. Water rods have been used successfully in mine-pump connections, and every hydraulic press is practically a hydraulic lever, and surely the difficulties to be overcome in the matter of leakage are not so insuperable as to make a determined effort unadvisable.

THE YOUNG MECHANIC

Conducted by Frank Richards.

THE genial spring and the early summer freshness draw us out of doors and we see the work of the garden and the farm going on. Nothing draws our attention more than the pruning of the vines, which is always to us more or less a heart-breaking process. That things should grow so lustily, and then be cut off from their share in the fruition, cannot but savor of waste and disappointment. But now a new and a still more outrageous style of pruning is proposed. To promote the healthy and vigorous growth of the young mechanic they are going to cut off his roots! Witness the following fresh clipping:

> A council of pedagogues has decided that the cube root must be eliminated from rudimentary instruction in arithmetic. In the early days the schoolmaster explained the problem very lucidly by the use of wooden blocks and birch switches. But there has been a great decrease in the timber supply, and hence the study may have increased in cost. Anyway, it is of very little use in ordinary business, and the modern student can find something more engaging in the study of "puts and calls."—*Troy Times.*

This proposition should not be a surprise to anybody. It is no more than should be expected as things go, and the flippant tone in which the suggestion is conveyed is of a piece with the rest of it. If any one will look into one of the "practical" arithmetics of the day he will get an impression that it is gotten up for a class of young brokers and bankers and general financiers, and he will find it hard to believe that it is really for the preliminary training, or, rather, for the entire school instruction of those who are to fill our workshops and factories and to carry on all the practical operations wherein the masses of our population are actually employed. The generally excellent arithmetic in use in the schools of New York city has about one-quarter of its entire bulk devoted to rules and examples under the general head of "percentage" alone. It is no wonder that the two or three pages taken up by "cube root" are to be crowded out. If the importance of the subject is to be estimated by the space occupied it is of course insignificant.

But the proposition means more than at first it seems to. Evolution and involution are correlated and interdependent, and to strike out one is to strike out the other. The cube root is the key to all computations relating to the weights and dimensions and general mensuration of all solid bodies. Yet this "is of very little use in ordinary business."! It is of no importance that those who are to handle our wood and stone and iron and earth in buildings and machinery and general engineering works should have any knowledge of what they are about! If the cube root is of little value, why not cut off the square root too? It can't be said that it is of any more importance than the cube root, and if one is worthless the other is equally so. Surely destructive pruning betrays the incompetent horticulturist. It would seem to be the business of the teacher not only to teach but also to know what to teach that will be of most service to the scholar, and when he makes such a suggestion as we refer to what are we to think of him? Would it not be well to prune his roots a little?

IT was always a mistake, and with our progress in all things it is becoming every day a greater one, that little education is needed for the working mechanic. Everybody knows more and has to know more than people used to, and why shouldn't he? Yet it is still common enough for a man to bring his boy to the shop with the tale that he will not learn anything at school and that therefore he ought to "go to work." In such a case the man as well as the boy needs to know more. If the boy succeeds in getting into the shop—and the writer hereof would not take him unless there were other circumstances to change the aspect of the case—a double injustice is perpetrated. The boy is handicapped by his lack of brain tools, and the proprietor is saddled with a more or less incompetent worker. A shop-foreman of these days would tell you that one of his chief troubles with the apprentices in the shop is in their ignorance of the elementary laws of physics. The principle of the lever, the elements of geometry, the values of direct and indirect forces, the relative strength of materials, have to be learned at the expense of the business. Where, years ago, "natural philosophy" was one of the elementary studies, "physics" now belongs to the advanced classes, and the boy that goes into the shop to-day is apt to go there without as much of such knowledge as he would have carried with him a generation ago.

The "practical" in education should have reference, not to the ideal, but to the actual prospective needs of those who are to be educated. The ideal of course is that we are all to be bankers and merchants and proprietors, while the actual fact is that many of us will be running lathes and all kinds of machinery, and doing active and responsible work in all the trades, and it will be no mistake to keep this in view in the common school.

BUT while we believe in as full a schooling as possible for the young mechanic before he gets into the shop, we readily admit there are other schools besides the common schools. Any agency that will promote the habit of finding out things, and the way of doing things, and the habit of actually doing things is better than the most thorough storing of the mind with facts. Common sense is not always supplied by the common schools, but there is no getting on successfully without it. In things mechanical it is especially valuable. It leads to the doing of things by the most direct methods, and to the taking advantage of circumstances everywhere.

IT will be noticed that we have at the head of this Department a little picture of a messenger boy that we have put to run a lathe. Now it happens, curiously enough, that we are entirely ignorant of his public-school record, but he certainly did not get into our shop upon the assumption that, because he was a failure at one thing, he must be a success at something else. He was not a failure as a messenger boy, but, on the contrary, he was a phenomenal success at it. His route was in Brooklyn, and by his perambulations of its streets he became especially expert in everything relating to oblique angles, which special knowledge is likely in time to prove nearly as valuable to him in the shop as an equal knowledge of figures would be. As a messenger he had considerable training in the most direct methods of getting to wherever he wanted to go. If he didn't know the way he was more apt to ask the driver of a fire-engine than to ask a policeman, and, if neither of them could tell him, he went along and found his way without their help. In the machine-shop we are very confident that he will not be asking us how to change the stroke of a shaper, or, if he has a belt to lace, he won't want any one to tell him whether it is an open or a crossed belt. He will never be writing to a mechanical journal after the style of a certain foundry-foreman who once actually wrote the following inquiry: "As I have experienced some difficulty in lifting molding flasks, owing to the giving away of the chains, I would be very much pleased if you could give me some information as to the weight of molding sand when rammed up in a flask. The giving away of a chain when lifting a flask is a source of considerable annoyance to the molder, and an answer to my question will therefore be of interest to other readers." No doubt the "foreman" in writing this thought that he was doing a big thing. Of course he was flattering himself that he was exercising—and displaying—an inquiring mind, which is said to be a good thing to have. Well, all we can say is that, if our messenger-boy machinist, two weeks in the shop, asked us such a question, he would be likely to be snapped up very short, and he wouldn't get any answer to his question unless our constant readiness to do a kindness let it slip before we had a chance to brace up. Don't think us severe. Here was a man, a full-grown man, a man from his position assumed to have some mental and executive ability, with the sand and the scales right beside him, writing off to Chicago, or New York, or Boston, to get somebody to tell him how much the sand weighs. The editor, who ought to know better, hunts up the weight of sand in some "pocket-book," which is probably accessible to the foreman also, and tells as nearly as he can guess what the foreman wants to know, and the foreman has had the pleasure of displaying his inquiring mind and is encouraged to ask again. "He that fights and runs away" will, contrary to the common tradition, live to run away again next time, and he who asks, instead of thinking and acting, will become more expert at asking than at thinking and doing, and will be evermore a framer of questions rather than of answers, and his notable deeds will be few.

As we took pains, at the opening of this Department, to invite correspondence upon mechanical topics, in the hope that something might come out of it of interest or benefit to some of us, we need not waste our time in saying that our correspondents when they do favor us are welcome. Here is an interesting letter:

DEAR MR. GRUMBLER:

I have been working in the shop here, learning the machinist trade. I don't get a chance to learn very fast because I have to do the same thing over and over again so much. I have been running a planer now for a week, planing a lot of pieces all just alike, and of course when I have done one or two there is nothing more to be learned at that, and so I have to wait until something better comes along to be done. I do get a chance to do different things once in a while. I can temper a lathe-tool as well as any fellow in the shop, but when it comes to annealing a piece of steel I don't seem to have much luck, and that is what I want to ask you about. Is there any secret about annealing steel that I haven't got hold of? If you can give me any points on this subject I will be much obliged.

M. T. J.

MR. M. T. J.:

Dear Sir: I am glad to receive your letter and will do what I can to give you an encouraging, if not altogether satisfactory, answer. If it will be any help to you, I will say that I think you are getting along better than you seem to think that you are. I have no doubt that you are learning every day. Many of our ideas, much of our knowledge, gets into us without our cognizance. There is very little formal teaching in life and what is undertaken in that line is not always a pronounced success. The learning that goes on is mostly through the personal act of the scholar in seizing and appropriating what comes within his reach. When we get grown up we don't generally expect to have the bread and butter and potatoes shoved into our mouths, but are content to feed ourselves. But when it comes to knowledge and skill many of us have an idea that it is to be crammed into us by teachers, and that if we have not the teacher our minds will starve. This is all a mistake. All that can be done at best is to set things before us and we must reach out and help ourselves, and if they are not set before us in inviting array we have only to reach a little farther and hunt a little keener. Discontent in a young and growing mind is only appetite, and there could be no health without it. You do not seem to be without the opportunity or the means of continually picking up knowledge as you go along, and you seem also to be profitably using your means and opportunities, and what more could you expect?

To be able to temper steel successfully is a great thing gained, in the machine-shop or in any of the lines connected with it. The operation of annealing steel is essentially a much simpler operation than that of tempering steel, and yet it is an operation attended with more failures, or with more varying degrees of success, than almost any other in the trade. Full and complete instructions for annealing steel may be put into a single sentence, and nine-tenths of those who try to follow the instructions will then fail of complete success in the operation; but, after all, the failure will be because the instructions are not implicitly followed. If I were to give instructions for annealing a piece of steel I would say (and I think my instructions would be complete): Heat the steel slowly, evenly, and thoroughly, and then let it cool slowly, and it will be annealed. This would seem to be simple enough and easy enough to follow. The steel, whether for hardening and tempering or for annealing, and especially for annealing, should be heated as hot as it may safely be done without injury to the steel. Unfortunately, we have no sure test for the heating of a piece of steel in the fire. We have practically no better test of the heat of a piece of steel than Tubal Cain had. The only guide that we have is the eye, and it is scarcely to be expected that an inexperienced eye can unerringly determine so delicate a shade of color as the difference between just hot enough in a piece of steel and a little too hot. I have an idea that the eye of an expert tool-dresser must be as keenly sensitive to certain shades of color as the eye of an artist. The blacksmith, unfortunately, deals with absolute shades of color, while the artist's colors are mostly relative to the other tones of his picture. The absolute color to which it is proper to heat a piece of steel has to be judged by the blacksmith under different lights, varying with the hour of the day and the state of the weather, which makes it still more difficult. Different steels will stand different degrees of heat and this also has to be learned, and learned mostly by failures, and if, as Dr. Holmes says, an oculist spoils a hatful of eyes before he becomes an expert, the tool-dresser may still be hopeful of achieving a magnificent success if he has not spoiled more than a cartload of tools in the heating. If it were not for the encouragement that we get from the knowledge of the failures of others we would not have power enough in our lives to drive us along.

But after all I think that failures in annealing steel are rarely in the heating of it. The trouble is entirely in the cooling, and especially in the beginning of the cooling. Just at that point occurs a little fatal spot where we fail to follow our instructions implicitly. We make great display of our annealing-box of lime or charcoal or sand or other non-conducting material, where the steel may cool as slowly as you please, and when we get our piece of steel embedded in that and covered up snugly, we have done our full duty by it, and then if it is not as soft as cheese it is not our fault. The one little loophole where failure so often slips in is in the fact that we often allow the steel to be chilled a little before we get our slowly-cooling arrangements to operate upon it. We handle the piece with cold tongs, or with tongs much colder than the steel. The annealing-box is stuck in an out-of-the-way corner, and in our hurry we rush our piece through the cold air and that chills it, and when we get to the place where we are to bury it the annealing material may be as cold as the grave. Although it may be very effective non-conducting material, when it gets at its non-conducting work, it has first to be heated, and this heating chills the steel, and, no matter how slowly the after cooling may be effected, it is too late to do much good. If there is any "secret" about annealing steel I think that right here is the place to look for it, and if I succeed in getting you to look in this direction you will need no further directions from me. Handle your piece with hot tongs, have your annealing-box as near the fire as possible and have its contents red-hot before you put your steel in. The last of the cooling is not of much importance and it is by no means necessary to keep the steel in the box until it is cool enough to handle with your bare hands. No harm can come to it when it has got down to 500° or so.

Kindly let me know what success you have, and I will be glad to hear from you again, whether you have any success or not. Yours truly,

DYSPEPTIC GRUMBLER.

ON May 5 occurred the formal opening and dedicatory exercises of the Webb Academy and Home for Shipbuilders. The exercises, conducted by Mr. Webb, were of the highest interest, the addresses being by Bishop Potter, the Rev. Dr. Collyer, and the Hon. Joseph H. Choate. No higher praise could be accorded the addresses than that they were eminently characteristic and worthy of the highest reputation of each distinguished speaker. They were of course highly eulogistic, or, let us rather say, worthily appreciative of the giver and the gift. The edifice, which is an imposing and everyway admirable one, well adapted to the uses for which it is designed, stands on Fordham Heights, overlooking the Harlem river, all of upper Greater New York, the Hudson, and the Palisades, one of the finest sites to be found in the whole breadth of our favored land. The ample grounds, the building, its equipment and liberal endowment fund are the exclusive gift of Mr. W. H. Webb, the eminent American shipbuilder. The total outlay involved is more than $2,000,000. It is given to few in this world to know such a moment of joy as must have belonged to Mr. Webb upon the complete accomplishment of so excellent a scheme of beneficence.

The purposes of the institution seem to be nearly equally divided between the provision for the declining years of aged and indigent shipbuilders and the provision for the opening years of many young shipbuilders by their education in the line of their special calling, and it preperly finds mention here on account of the latter of its functions. The establishment is the highest expression of the profound conviction of a thorough and world approved experience as to the necessity and value of education as a help to success in an important field of activity. A man who has been remarkably successful in an honored sphere of activity, now in the years of his ripest wisdom, with his heart full of a desire to do with his means what shall be best and most helpful for his fellows, puts his conviction in this enduring form. No living man can do other than wish the institution the highest success, nor refrain from hoping that it may graduate those who will be worthy rivals of Mr. Webb in the front rank of American shipbuilders.

Mr. Webb can doubtless tell us, as other successful men have told us, of the insufficiency of his early education, of his struggles by candle-light, in the intervals between days of hard toil, to store his mind with necessary knowledge, and of the determination that grew therefrom that some others should be better equipped than he was in the line of his special calling. No doubt Mr. Webb may often have thought how much greater would have been his success if he in his day had possessed the boon of a more liberal education. In this the world will probably not agree with him, and the institution which he has so nobly endowed for educational purposes will be, in spite of him, a monument to the self-educated man, and an enduring sign of encouragement to those who have not received the highest ministrations of the schools to still manfully and hopefully do their level best.

COMMENT & CRITICISM

The Sanitary Survey of Santos.

THE sanitary survey of the Brazilian town of Santos by American engieers, noticed in the Civil Engineering department in this Magazine for May, may prove to be of more importance to the people of the United States than any other movement in Spanish America in recent times. It can not be doubted that very many interests in the United States, which otherwise might have been benefited by an extension of trade with the South American republics, have been handicapped by the dread on the part of our people of coming in contact with climatic and other conditions which they have deemed unhealthful. This is not to be wondered at when the death-rate from yellow fever in the town of Santos has been 124 per 1000 inhabitants per year. The recent war in Brazil, though furnishing columns of news for the journals of every nation, was an insignificant affair compared with the death-rate of 100 per day from yellow fever alone in the city of Rio de Janeiro. The spirit of enterprise and progress which is making itself felt in so many centers in South America cannot fail to gain an impetus from the lesson furnished by Santos, if the work outlined by Professor Fuertes and Mr. Hering should be prosecuted to completion. The result upon the death-rate there may be expected to be a repetition of the experience of Memphis and other cities in the southern United States, once dreaded by so many people as pest-holes, which now have, through acceptance of the advice of sanitary engineers, reduced their mortality rate to normal figures. The result in the case of these cities has been a steady growth in population and an important increase in industry and commerce. The adoption by Santos of quarantine, of a proper water-supply, and of a rational system of sewerage can hardly fail to be observed by the capitals of the other Brazilian states, as well as the leading cities elsewhere in South America. The important shipping-port of Pará, at the mouth of the Amazon, which furnishes the world's most important supply of india-rubber, is scarcely without a resident from the United States, although the manufacturers of this country consume by far the larger share of the rubber product of the Amazon valley. The small number of Americans engaged in trade on South American soil was emphasized by the reference to Argentine in the paper in this Magazine last month on "America's Need of Wider Markets." That the danger from the unhealthful conditions of Spanish America, bad as they are, has been exaggerated in the minds of the people of the United States, is proved by the fact that important colonies from so many European countries have been established and maintained all the way from Colombia to the river Plate. It is encouraging, therefore, to know that the value of good sanitation is becoming appreciated in the great continent to the south of us, for this fact alone will do much to encourage more thorough investigation of that continent by our engineers and representatives of our commercial classes, who can now hardly be tempted to undertake commissions there even by the offer of extraordinary rates of compensation. H. H.

The Opportunity in Peru.

SEÑOR ANTONIO RAIMONDI, the eminent scientist of Lima, once said, when speaking of his own country: "It appears to me a thing incredible that Peru—this land of proverbial wealth—which, at the time of the Spanish conquest, filled with gold the chests of the exhausted Spanish treasury, has been, up to the present time, almost a *terra incognita* to the people of Europe." And an English nobleman lately declared, upon a public occasion, that he could not understand how it was that his countrymen should take so much interest in Africa and so little in South America.

Contrasting the facts respecting Peru which Mr. Guillaume presents in the Magazine this month with the facts universally admitted with regard to Africa, it does seem incomprehensible that so many great powers should be engaged in a contest over the latter while almost overlooking the former, except on the idea that their hope of continued commercial greatness is in keeping as much of the world as possible under political subjection. The spirit of independence is too rife on South American soil for crown colonies to exist there. Even remote Peru has preferred to remain poor and obscure rather than wear the yoke of any old-world power. It is something for the young republic to have maintained its independence for seventy-three years, and to have made real progress and escaped total bankruptcy; the fact that it has not done more argues nothing against the country's wealth of natural advantages.

The nations of Europe have not hesitated, when Peru has appeared as a buyer, to supply her wants, but there is a further interest in the development of such a country that might prove mutually profitable. When representative citizens of a certain southern state once appeared in New York to invite the interest of a great capitalist in the mineral wealth of their section, he is reported to have doubted all of their statements, " for," said he, " if they had such resources they were fools not to develop them themselves." Later he learned that, though a whole state might be underlaid with rich iron-ore, the people might not have the skill or the financial ability to carry any part of it to market. So with Peru; without appealing for a lift, but while doing her utmost to train her sons to help themselves, the little republic does invite outsiders to occupy her lands and mine her metals and extend her railroads, on such terms as shall yield a profit all around.

To such a field the attention of enterprising Americans may well be invited—not only to Peru, which happens to be brought before our readers this month, but to others of our neighbors in the far south as well. It is not enough to profit by staying at home and selling a sugar-mill or mining plant if such should happen to be ordered. Real enterprise consists in going abroad and creating a demand—by the investment of capital, if need be—for what we are prepared to manufacture. By the way, it is worth noting that, irrespective of the sources of the capital expended in Peru, some of the most important engineering constructions there have given employment already to American talent and to American materials.

There is even less reason that Peru and her neighbors should be an unknown part of the world to the people of the United States than that they should be unknown to the people of Europe. The fact is, that the continuation of existing conditions much longer will lay our people open to the reproach—never before justly charged against us—of lacking in enterprise. Yet intelligence and judgment must be used before one plunges too deeply into a field for business so different from that which exists at our own homes. Peru is farther from New York than Nevada if disaster should befall any enthusiastic prospector.

H. H.

Wind-Mills and Electricity.

In the March number of the Magazine, in the department of Electricity, appears a notice of an electric-lighting plant driven by wind-power, which has been for some time in successful operation in Jersey City; giving about three-horse power with a wind-wheel diameter of eighteen feet and a wind speed of about twenty miles an hour. These details are not entirely in harmony with the efficiency noted in a preceding article on wind-mills, by Professor Thurston. I should be pleased to see in your Magazine an article on this subject in detail, with drawings, if possible, giving the efficiency of wind-mills in generating power for electrical uses.

In many places on the Pacific coast, in fact, throughout the whole length of the western side of the range, the trade-wind is about as regular as the sunshine for about more than half of the year. If the land-owners here could get exact information on the matter mentioned, it doubtless would result in the establishment of many electrical plants on the coast for lighting and other purposes. I have a "seaside home" where I find plenty of wind for several months every year, where one plant would be sufficient to provide lights for a number of houses, and it would be desirable for such places to have an estimate of actual efficiency and cost of plant.

S. S. SOUTHWORTH.

Sacramento, Cal., March 14, 1894.

Electric Haulage in Mines.

IN the department of Electricity in the May number of this Magazine appears a brief description of an electric-haulage plant in use in the Bear Run mines of the Blossburg Coal Co., Tioga county, Pa. A mine-operator reading the description mentioned might suppose that one of these 30-horse-power locomotives would haul thirty-two loaded wagons, weighing 3200 pounds each, up a 3-per-cent. grade at a speed of six miles per hour, and, upon this basis, might be tempted to order a locomotive having such a capacity for use in his own mine, where he had a similar grade. Should he do this he would find that, instead of hauling thirty-two cars, it would be doubtful if he could pull more than fifteen such cars. Space does not permit my entering into particulars of the size of locomotives required for such loads, but, in view of the wide difference between the capacity of locomotives required for certain work and that quoted in the Magazine, some comment should be made upon the figures given. Seventy-five per cent. of the electric-haulage plants in the United States have been constructed from the writer's designs, and he has found that the weight of a locomotive required for pulling a load up a grade in a mine is much greater than the power required on a surface road, on account (1) of the greasy condition that the track is generally in, and (2) of the bad alignment of track. The weight of the locomotive, instead of being only 7500 pounds, as stated, is really 11,500 pounds.

CYRUS ROBINSON, M. E.

Columbus, Ohio, May 7, 1894.

A Correction.

BY an inadvertence in the printing of this Magazine an engraving appears on page 404, as "Figure 10," the use of which was not intended, while the proper cut does not appear at all.

CURRENT TECHNICAL LITERATURE

TIDAL RIVERS. THEIR (1) HYDRAULICS, (2) IMPROVEMENT, (3) Navigation. By W. H. Wheeler, M. Inst. C. E., author of "The Drainage of Fens and Low Lands by Gravitation and Steam-Power." (Longmans' Civil Engineering Series.) London and New York: Longmans, Green & Co. [Cloth. 8vo. viii-467 p. $5.]

THE old adage that "what is worth doing at all is worth doing well" has nowhere a greater significance than in the writing of technical reference-books, for it is an unfortunate fact that, when erroneous conclusions are drawn from special observations made by experimenters of recognized ability, the published results may be quoted as authentic for a century afterward. The science of hydraulic engineering covers such a vast field of experimental knowledge that every engineer is often obliged to accept on faith the published conclusions and results of the investigations of his predecessors. Where conclusions have been deduced without regard to the relative conditions, designs based on such conclusions may totally fail to produce anticipated results.

Mr. Wheeler's volume on tidal rivers will be a valuable addition to the library of any maritime engineer, yet in the above-named regard the work is no exception; in fact, if the whole of the chapter on "the transporting power of water" were expunged, the value of the work, as a book of reference, would be greatly enhanced. More than a century ago, Dubuat made a series of experiments with water flowing in shallow troughs to determine its transporting power at different velocities, and, although the results thus obtained have not the slightest bearing on what may occur in streams of greater depths, there is scarcely a reference-book on hydraulic engineering that does not quote Dubuat's values as authentic. To expect that any given velocity of flow, without regard to depth and volume of stream, will erode and transport particles or pebbles of a given size, is equivalent of assuming that an equation of two unknown quantities may be solved with one equation of condition.

The author also quotes Airy, Law, and Hopkins as authorities for the statement that the power of a stream to move bodies along the bottom varies as the sixth power of the velocity of flow. Since he admits that the energy of any stream to tear up particles adhering to the bottom only varies as the square of the velocity, it is hard to conceive how such power is suddenly increased to the sixth power of the velocity as soon as the particle commences to move, when the relative velocity is correspondingly decreased. It is true that the author of the book is not responsible for the errors of the works quoted, but, in quoting them without qualifying comment, he perpetuates the error and becomes equally subject to criticism.

The chapter on "tides" is a clear and concise discussion of the phenomenon in all its phases, from the development of the tidal wave in the Southern ocean to the ebb and flow in the various rivers and harbors of the world, and cannot fail to be of great interest to the reader who wishes to know what actually does occur, and does not care for the mathematical demonstration of the theory. The author could not resist the temptation, however, to do a little guess-work in some cases, where the cause of certain tidal phenomena was not entirely clear. And in undertaking to explain why there is but one tide each day in the Gulf of Mexico he says: "This may probably be due to the fact that the flood-tide, being driven into the gulf by the momentum of the ocean wave, and having a long run up the Mississippi and other large rivers which are connected with the gulf, pours so great a quantity of water into the gulf that the ebb has not time to get out again before it is met by the succeeding flood, and consequently only every alternate wave reaches the head of the bay." Since the total ebb flow of all the gulf rivers for one tide is not sufficient to raise the gulf level $\frac{1}{10000}$ part of an inch, it is quite evident that the reason given is not tenable.

The chapters on the physical conditions of tidal rivers, the formation of bars at their mouths, and the principles to be observed in making improvements, show a careful study of the phenomena and generally correct conclusions as to best methods of amelioration. The physical characteristics of many American harbors, however, are so different from those of Europe that American hydraulic engineers will hardly be inclined to accept all the principles stated, as, for instance, "that a fresh-water stream is powerless to maintain a sea outlet and to keep down a bar."

Under the heads of "training," "dredging," and "examples of river improvement" a concise history is given of the methods employed, and the cost of the improvements that have been executed at the principal harbors of Europe. Full references are given to reports and papers relating to the various projects, so that the reader may readily look up the details of any particular enterprise in which he may be interested.

The style and general make-up of the book are good, and, although some of the views advanced will probably not meet the approval of experienced engineers, it will, no doubt, be read with great interest by all engineers interested in the development and improvement of tidal rivers.

GEORGE Y. WISNER.

Detroit, Mich., May 1, 1894.

ELEMENTARY METAL-WORK. A PRACTICAL MANUAL for Amateurs and for Use in Schools. By Charles Godfrey Leland. New York: Macmillan & Co. London: Whitaker & Co. [Cloth. 8vo. 111 p. $1.50.]

THERE is, at present, a revival in artistic metal-working, and iron-work is now regularly turned out from shops that rivals in beauty the productions of the most famous of medieval artists. It is needless to say that all malleable metals share with iron its possibilities for art purposes, except as preliminary to the remark that the book under notice, while dealing principally with iron as the most readily available material for the object of instruction in metal work, includes in its scope the treatment of all metals susceptible of being bent or wrought, cold or hot, by hammering, swaging, etc., into beautiful and decorative forms. One can scarcely conceive of a more delightful occupation wherewith to fill leisure hours than the kind of work herein described, which, in its lighter forms, is equally adapted to both sexes. But there is also an active commercial demand at remunerative prices for this kind of work, and those who possess cultivated artistic sense and excel in the execution of decorative metal-work readily find employment in it at good wages. The author is well known in America and Europe as the writer of many other treatises on art-work of various kinds, and was, until recently, director of industrial-art work in the public schools of Philadelphia. The most conspicuous feature of the work is its insistence upon the thorough mastery of elementary principles and manipulations, one after another, in due order, before attempts at even moderately elaborate work are essayed. In this the author accords with the views of the best educators in all branches of manual art; but in his book he adheres to this system much more strictly than is usual with instructors, who sometimes preach a doctrine they do not rigidly practise. The kinds of work upon which the treatise gives ample and systematic instruction are bent-iron or strip work; flat-sheet metal-work; molded sheet-metal work; repoussé or embossed-metal work; ornamental silver-work, and nail-, scale-, and stencil-work. The directions given for the execution of all these kinds of work begin with the most simple forms and progress by easy steps to more complicated designs. The text is exemplified by 124 well-executed illustrations and, on the whole, seems so complete a guide to the arts of which it treats as almost to take the place of a living teacher. A multitude of youths of both sexes would be much benefited by having this book placed in their possession, together with the needed implements and materials (all of which are described in it) for the cultivation of skill in this pleasant, and, to adepts, profitable art. Most potent influences in the early molding of character are interesting and innocent occupations exercising the constructive faculties, and the cultivation of taste for, and a love of, beautiful things. These, supplanting lower and baser influences, oppose what otherwise often leads to evil courses. The cover of Mr. Leland's book bears a tasteful design, emblematic of the art to which the work is devoted, which was evidently supplied by its accomplished author. LEICESTER ALLEN.

THE MECHANICS OF HOISTING-MACHINERY, INCLUDING Accumulators, Excavators, and Pile-Drivers. A Text-Book for Technical Schools and a Guide for Practical Engineers. By Dr. Julius Weisbach and Gustav Hermann. Authorized Translation from the Second German Edition, by Karl P. Dahlstrom, M. E., late Instructor in Mechanical Engineering at the Lehigh University. With 177 Illustrations. London and New York: Macmillan. [Cloth. 8vo. 329 p. $3.75.]

THIS volume comes like an old friend, although it has never appeared in English before. No author, perhaps, is more familiar to or more highly prized by engineers throughout the world than Weisbach. More engineers undoubtedly have been " brought up " on Weisbach than on any other authority, and his clear and simple notation and concise and incisive methods of analysis of the application of the principles of mechanics have become so well known as to be almost recognizable wherever found, even though they bear no other imprint of the author than that of his own individuality. Other portions of Weisbach's great work on engineering mechanics have found translators in Coxe, Dubois and Klein, treating respectively of theoretical mechanics, steam-engines and hydraulics, and machinery of transmission, and it has been through these translations that those who have not been able to study the subjects in the original have been able to become acquainted with the author. They have in fact become so popular and well known as text-books in our leading engineering schools that the volume before us needs no further introduction or higher commendation than the mere statement that it is another chapter in the series and that it maintains the same high standard of excellence. The book is divided into eight chapters devoted respectively to the following subjects: levers and jacks; tackle and differential blocks; windlasses, winches and lifts; hydraulic hoists; accumulators and pneumatic hoists; hoisting-machinery for mines; cranes and shears; excavators and dredges, and pile-drivers. The treatment is simple and direct and involves no mathematics higher than trigonometry. The illustrations are usually good and amply abundant. They seem also, where concrete examples are given, to be brought nearly down to date. This is particularly noticeable in windlasses, winches and lifts, mine-hoists, cranes and shears, and excavators and dredges. The book has an effective index.

MINING: AN ELEMENTARY TREATISE ON THE GETTING of Minerals. By Arnold Lupton, F. M., M. I. C. E., F. G. S. London and New York: Longmans, Green & Co. [Cloth. 8vo. xxiv-519 p., with 596 illustrations. $3.]

THE modest appellation " an elementary treatise," by no means gives a fair impression of the scope and character of this work. On the contrary, within the limitations necessarily involved in any attempt to cover the whole field of mining in a single volume, it is a very thorough-going and practical work; certainly no one book on mining comes nearer the mark, though there are numberless works treating special branches in more detail.

One of the first things that strikes the reader is the admirably simple, direct, clear style of the text. There are no words wasted; everything is to the point. For example, in the opening chapter, on geology—an inviting field for diffuseness and theorizing—the author presents as complete a review of known facts as need be desired by the practical miner who wishes to obtain a summary of general geology, as now understood by common consensus; though a little more information about ore deposits might be pertinent. The same remark holds good as to all succeeding chapters—which relate to exploration, boring, winning (or mode of approaching the mineral), sinking and sinking-machines, opening out, methods of working different substances, ventilation, chemistry of mines, coal-dust (dangers and remedies), safety-lamps, blasting, power-drills and heading-machines, coal-cutting machinery, timbering, underground haulage, transmission of power, winding-engines, pit-frames and hoisting-apparatus, safeties, pumping-engines and pumps, treatment of mineral at surface, miners' tools, etc.

While the book touches upon all branches of mining, it is more particularly devoted to coal-mining, yet is not altogether unbalanced on that account.

It is an English book. That means of course that it contains much to which American engineers may—and justly, I think—take exception. Methods and appliances which are standard in English and continental practice certainly do not always answer in the United States. Yet as foreign engineers—and the distinguished author not less than any—are acquainted with American machines and methods, but persistently retain in many cases those which we here consider obsolete, they must at least be credited with doing so after full consideration of differences of conditions. It is precisely the same with mining as with railroading: where methods diverge it is safe to assume that those adopted in one country are best suited to it, while those followed in another are likewise proper. Else we would be forced to believe that the engineering talent and judgment of one nationality are inferior to those of another—which would lead to a senseless and ill-tempered wrangle over matters about which we agree to differ amicably, respecting each other's opinions and predilections and allowing for circumstances. When, for instance, we read detailed accounts of construction of circular brick- or masonry-lined shafts, of say 15 to 20 feet diameter, or of mine-tunnels built on the same plan, we are reminded of the rigid British locomotive (and the old controversy over it and the American pattern), yet neither, however unsuited to conditions here, is to be laughed at. English practice is slow and sure, solid and permanent; very conservative in adhering to precedents, so that advances are mostly made along well-defined lines by successive improvements. Here we are satisfied with lighter construction, look to more rapid returns for investment, and are more ready to devise and adopt new methods to fit special cases.

But if Mr. Lupton's book is British, it is not so in a bigoted or pedantic fashion. Indeed, the very fact that it is more especially devoted to European methods commends it to American readers. Those of us who have not had the advantage of inspecting foreign mines have to rely upon the books and the technical journals for information; and we want that information in just the precision here given, in order that we may not become narrow-minded and prejudiced in favor of local customs. For that matter, there is no real dispute as to essential principles—or else engineering would be a farce. It is in the details and means of reaching certain results that practice varies.

Perhaps the plainest compliment to be paid to "Mining" is to say that, while a reviewer is usually content to skim over a few pages here and there to get an idea of the merits of a book, and satisfies his conscience with this perfunctory survey, and while an engineer seldom reads through such books for the sake of reading them, but uses them in part for reference, in this case the reviewer confesses to having gone over every page (barring tables, etc.), because each commanded attention, before penning this notice. The author must excuse the naïveté of the compliment in view of its sincerity. A. W., JR.

PATENT-OFFICE MANUAL, INCLUDING THE LAW AND Practice of Cases in the United States Patent Office and the Courts Holding a Revisory Relation Thereto. By George H. Knight. Boston: Little, Brown & Co. [Sheep. 8vo. 655 p. $5.]

THE author of this manual brings to his work the practical experience of more than half a century, during much of which time he has been a patent solicitor and an expert in his profession. Its object, after discussing the nature of the patent franchise, is to afford patent solicitors, lawyers engaged in patent practice, and inventors a compact handbook on the application for a patent and its preparation and prosecution. It embraces, in excellent arrangement, a summary of the more important decisions, up to date, relating to patents for inventions and designs and also to trade-marks and labels. These summaries are satisfactorily prepared, and are supplemented by copious references to cases which illustrate or which seem to qualify or form exceptions to general rules.

THE ELECTRIC TRANSFORMATION OF POWER AND ITS Application by the Electric Motor, Including Electric Railway Construction. By Philip Atkinson, A. M., Ph.D. New York: D. Van Nostrand & Co. London: Crosby, Lockwood & Son. [Cloth. 8vo, 233 p.]

THIS is another of the very many cheap attempts to supply so-called popular electrical literature merely for the sake of whatever profit there may be in issuing a book of late date. The author does not fall into as many errors as some other makers of such books, and this must be marked down to his credit, but the general character of the publication reminds one forcibly of those portions of the American electrical journals devoted to gratuitous trade notices of the electrical apparatus of their advertisers. It has more merit than they, but there is scarcely room for another such book and we are sorry to see this one.

A POCKET-BOOK OF ELECTRICAL ENGINEERING FORMULÆ. By W. Geipel, M. I. E. E., and M. Hamilton Kilgour, Asso. I. E. E. and M. P. Soc. London: *The Electrician* Printing and Publishing Co., Limited. [Leather. 758 p., with index. 7*s.* 6*d.*]

THIS work is fully in keeping with the high standard usually maintained by the books issued from *The Electrician* press. It is the most ambitious attempt thus far made to produce an all-embracing pocket reference-book for electricians. At first sight it would appear that the title *electrical* engineering formulæ was an ill-chosen one, for we find within its covers much space devoted to formulæ and other matter not strictly electrical. For instance, we find such formulæ as those for the determination of sound in various media; for determining the strength of materials; the trigonometric functions; tables of radius in terms of degrees; hyperbolic sines and cosines; differential coefficients and general integrals; standard screw-threads for gas-, water-, steam-, and hydraulic-tubes; formulæ for heating buildings, etc. But we must remember that the electrician must be all things to all men; that there is now no branch of engineering in which he may not be called to have his say; in fact, until the profession becomes more specialized he must in fact be a "jack-of-all-trades." While such conditions obtain there is scarcely any source of information which he can afford to neglect. His pocket-book of formulæ can therefore never be too comprehensive until it becomes too large to be a pocket-book.

This book has been criticised because it has not been confined to purely electrical formulæ, but in view of the, present state of the science, who shall say what are and what are not formulæ that the electrical engineer may be called upon at any moment to use? We think the value of the book is enhanced rather than depreciated by this additional matter.

MODERN AMERICAN PISTOLS AND REVOLVERS. BY A. C. Gould (Ralph Greenwood). Illustrated. New Revised Edition. Boston: Bradlee Whidden. [Cloth. 8vo. 222 p. $1.50.]

THIS is a well-written book by a well-known authority on fire-arms. In it are described all the modern American pistols and revolvers, many of which are well illustrated. It includes also reports of tests of pistols and revolvers at all ranges, by the author and by the ordnance board of the government; sights used for the various kinds of shooting; ammunition for pistols and revolvers, and their merits; directions for making ammunition; records of the performances of pistols and revolvers; diagrams of famous scores; portraits of famous American shots and the rules followed by shooting-clubs, the United States army and navy, and the National Guard.

WHAT AN ENGINEER SHOULD KNOW ABOUT ELECTRICITY. By Albert L. Clough, E. E. Illustrated. Boston: The Mason Regulator Co. [Paper. 12mo. 108 p. 50 cents]

THIS little brochure is a meritorious compilation of much useful electrical matter, including an authorized copy of the rules and requirements of the Underwriters' International Electric Association, for the installation of electric light and power. We have two criticisms to make, however. In the first place, the title is entirely too broad. Secondly, we seriously object to one's signing after his name the initials "E. E." If the author has such a degree from any reputable institution authorized to grant the degree of Electrical Engineer he is entitled to use it, of course; but if he has not, he places himself, by using it, in the same category as the boxing-master or horse-trainer who dubs himself "Professor." None of our leading electricians use the initials at present; it is considered bad form to use them.

JOURNAL OF THE ASSOCIATION OF ENGINEERING SOCIETIES. Published Monthly. Vol. XIII. No. 3; March, 1894. Philadelphia: John C. Trautwine, Jr., Secretary. [8vo. 30 cents, $3 per year.]

THIS well-known journal, in which are published the papers and proceedings of the eight engineering societies of Boston, Chicago, Cleveland, Kansas City, Minneapolis, Montana, St. Louis and St. Paul, and of the Wisconsin Polytechnic Society, has appeared in a new dress and presenting other novel and attractive features. Early in the present year Mr. John C. Trautwine, Jr., was made the secretary of the Association, and the publication office was removed to Philadelphia. Conspicuous among the innovations is the adoption of an enlarged type and an enlarged page. The editor has introduced, under the caption of "The Contribution Box," a department of notes and communications contributed chiefly by members of the several societies in the association, and one of book-notices. In addition, the *Journal* contains, as it has done for years, a valuable index to technical literature, prepared under the auspices of Professor J. B. Johnson, of Washington University, St. Louis.

The present number opens with a memoir of the late I. C. Chesbrough, whose portrait forms the frontispiece. Then follows a valuable discussion, held under the auspices of the Boston Society of Civil Engineers, upon the fruitful subject of the construction of reservoir embankments. In this discussion a number of our most prominent engineers describe their experience and state the views to which that experience has led them. A short paper by Mr. Arthur A. Skeels, of Cleveland, illustrates and describes a proposed new system of electric railroad signals.

NEW BOOKS OF THE MONTH.

Bancroft, Hubert Howe. = Resources and Development of Mexico. Published separately in English and Spanish. Illustrated. San Francisco and Chicago: The Bancroft Co. [Cloth. 8vo. $4.50.]

Brunor, Martin. = The Practical Electroplater. A comprehensive series on electroplating, with notes on ancient and modern gilding and formulæ for new solutions. Illustrated. New York: Emile Brunor. [Half leather. 12mo. $10.]

Birkmire, W. H. = Skeleton Construction in Buildings. New York: Wiley & Sons. [Cloth. 8vo. $3.]

Burn, R. Scott, *editor.* = The Steam-Engine User. Being practical descriptions and illustrations of the stationary engine in its various forms, with details of the boiler and furnace, their applications and fittings; of the engine with details of modern valve-gear, the multiple cylindered or compounded system of working, etc.; with descriptions and illustrations of heat prime movers other than the steam engine, by various writers. New York: Ward, Locke & Bowder, Limited. [Cloth. 8vo. 402 p. $2]

Cary, G. H. = How to Make and Use the Telephone. A practical treatise for amateurs with working drawings. Illustrated. Lynn, Mass.: Bubier Publishing Co. [Cloth. 16mo. 117 p. $1.]

Crandell, C. L. = Railway and Other Earthwork Tables. New York: Wiley & Sons. [Cloth. 8vo. $1.50.]

Crandell, C. L. = The Transition Curve. New York: Wiley & Sons. [Morocco. 12mo. $1.50.]

Fijnje Van Salverda, J. G. W. = Aërial Navigation. From the Dutch, by George E. Waring, Jr., with notes concerning some recent developments in the art. New York: Appleton. [Cloth. 12mo. 209 p. $1.25.]

Fiske, John. = Edward Livingston Youmans. A Sketch of his life, with selections from his published writings and extracts from his correspondence with Spencer, Huxley, Tyndall, and others. New York: Appleton. [Cloth. 8vo. 6-597 p. $2.]

Gorby, S. S. [State Geologist.] = Eighteenth Annual Report on the Geological and Natural Resources of Indiana, for 1893. With map of Quarries and Gas and Oil Fields. Indianapolis: W. B. Burford. [Cloth. 8vo. 356 p. No price.]

Haldane, J. W. C. = Steamships and Their Machinery; From First to Last. New York: Spon & Chamberlain. [Cloth. 12mo. $6.]

Henthorn, J. S., and Thurber C. D. = The Corliss Engine and Its Management. Edited by E. P. Watson. Third edition, with appendix by Emil Herter. New York: Spon & Chamberlain. [Cloth. 16mo. $1.]

Houston, Edwin J.—Outlines of Forestry; Or the elementary principles underlying the science of forestry. Philadelphia: Lippincott. [Cloth. 12mo. $1.]

Hughes, Norman. = The Manneto Hand Telephone. Its constitution, fitting up and general adaptability to every day use. Illustrated. New York: Spon & Chamberlain. [Cloth. 12mo. 80 p. $1.]

Huxley T. H.—Science and Christian Tradition. Essays. (Vol. V of Collected Essays.) New York: Appleton. [Cloth. 12mo. 34–419 p. $1.25.]

Ingersoll, Royal Rodney.—Text-Book of Ordnance and Gunnery. Compiled and arranged for the use of naval cadets, United States Naval Academy. Illustrated. Baltimore: The Author. [Half leather. 8vo. 264 p. $3, net.]

Johnson, J. B., Bryan, C. W., and Turneaure, T. E. = Theory and Practice in the Designing of Modern Frame Structures. New York: Wiley & Sons. [Cloth. 4to. $10.]

Johnson's Universal Cyclopedia. New and revised edition. Edited by C. Kendall Adams, assisted by Thirty-six editors of departments. Illustrated. In eight volumes. Vols. I–IV. New York: D. Appleton & Co. [Cloth. 8vo. $6 per volume.]

Kanschinger-Fürst, Herrman.—The Protection of Woodlands. Authorized treatise from the German of Kanschinger-Fürst's Waldschultz, by J. Nisbet. New York: W. R. Jenkins. [Cloth. 8vo. $3.50.]

Kelly, J. D. Jerrold.—Our Navy. Its Growth and Achievements. A History of the Navy of the United States from the beginning of our government. Illustrated by F. S. Cozzens. Hartford, Conn.: American Publishing Co. [Paper. 4to. $15. Edition de Luxe, $50.]

Kinney, Clesson S. = A Treatise on the Law of Irrigation. Giving all the case and statutory law in the United States. Washington: Lowdermilk. [Sheep. 8vo. $6.50, net.]

Langley, S. Pierpont.—The Internal Work of the Wind. Washington: Smithsonian Institution. [Paper. 8vo. 3–23 p. 25 cents.]

Leland, C. Godfrey. = Elementary Metalwork. A practical manual for amateurs and for use in schools. New York: Macmillan. [Cloth. 4to. 111 p. $1.50.]

Lick University Publications, Vol. II. = Double Star Observations from August, 1888, to June, 1892. By S. W. Burnham. Sacramento, Cal.: A. J. Johnston. [Cloth. 4to. 255 p. No price.]

Louis, H. = A Handbook of Gold-mining. Illustrated. New York: Macmillan. [Buckram. 8vo. 504 p. $3.25, net.]

Mauchline, Robert.—The Mine Foreman's Hand-book of Practical and Theoretical Information on the Opening, Ventilating of Collieries. Questions and Answers on practical and theoretical coal-mining. Designed to assist students and others in passing examinations for mine foremanship. New edition. Illustrated. Philadelphia: H. Carey Baird & Co. [Cloth. 8vo. 337 p. $3.75]

NEW TRADE CATALOGUES.

Any of these catalogues free on application to the manufacturers.

The Watts-Campbell Company, Newark, N. J. = Improved Corliss Steam Engines. 48 p. [Important information in steam engineering, etc.]

William A. Harris Steam Engine Company, Providence, R. I. = The Harris-Corliss Engine, 60 p. [Condensing engines, tandem compound engines, coupled engines, etc.]

Ames Iron Works, Oswego, N. Y. = High Speed Automatic Engines. 23 p. [Detailed specifications, tables, etc.]

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The Riker Electric Motor Company, Brooklyn, N. Y. = Electric Motors and Dynamos. 38 p.

The Interior Conduit and Insulation Company, New York. = Lundell Motors and Dynamos. 24 p. [Slow speed, direct current.]

Solar Carbon and Manufacturing Company, Pittsburgh, Pa. = Catalogue and Price-List. 26 p. [Experimental carbons a specialty.]

The Iona Manufacturing Co., Boston. = Electric Specialties. 20 p. [Sockets, cut-outs, switches, etc.]

The J. M. Carpenter Tap and Die Company, Pawtucket, R. I. = Taps, Dies, Screw-Plates, etc. 32 p.

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The Phœnix Automatic Filter Company, Racine, Wis. = A Practical Treatise on Oil-Filtration; Description of Filters. 40 p.

James A. Taylor & Co., Wilmington, Del. = American Standard Gage and Tool Works. 30 p. [After Richard's system; measuring instruments of precision; adjustable blade, shell, and rose chucking reamers.]

Eastern Electric Cable Company, Boston. = Wire Tables and Price List of the Clark Wire and Cables. 12 p.

The Buffalo Steam Pump Company, Buffalo, N. Y. = Steam Pumping Machinery. [64 p. [Useful information on steam and water pressure etc.]

THE

ENGINEERING MAGAZINE

VOL. VII. JULY, 1894. NO. 4.

THE DANGER LURKING BEHIND STRIKES.

ARE WE DRIFTING TOWARD STRONG GOVERNMENT?

By William Nelson Black.

PROBABLY no other people were ever so much attached to their government as the people of the United States have been during the hundred years of their independent career. The picture or statue of the first president is about as familiar to every man as his own face; and so completely has every native-born American trusted to the perfection of our institutions that when the great struggle over slavery came, and a new government was set up south of the Potomac, no attempt was made at any organic changes worth mentioning. The new government simply represented secession without revolution. Or, if differing in any essential particular from the old government, the difference would have been due to an attempt to get nearer to the spirit of the original model. When we reflect that every other civilized government exists in an alternating state of either chronic or paroxysmal revolution, the unchanging career of this country should be thought remarkable.

It has been said in the past that were an election held at any time to reconsider the form of our political constitution, the people would decide unanimously in favor of precisely the form which we now possess. But would the saying be true to-day? Symptoms are not wanting which serve to show that men are becoming dissatisfied with the organism of our political body; and these signs point not forward in the direction of greater freedom and more complete personal independence, but backward toward the socialism of ancient and feudal times.

Two forces are at work to shake the foundations of society all over

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Christendom. The first is made up of the mechanical workmen and laborers, men who, misconceiving the influences that have brought them out of barbarism and surrounded them with the advantages of civilization, are disposed to appeal to government to help them repress the man whom they think their enemy—the capitalist. The second is the capitalist himself, who feels his interests endangered by the assaults of the workmen, and is disposed to put the old gauntlets of tyranny and force on the hands of government for his own protection.

Many reflecting men will recall the recent declaration bearing upon social disorders and government made by Herbert Spencer in a tribute paid to the memory of Tyndall. The following is an extract:

> My faith in free institutions, originally strong (though always joined with the belief that the maintenance and success of them is a question of popular character), has in these later years been greatly decreased by the conviction that the fit character is not possessed by any people, nor is likely to be possessed for ages to come. A nation of which the legislators vote as they are bid, and of which the workers surrender their rights of selling their labor as they please, has neither the ideas nor the sentiments needed for the maintenance of liberty. Lacking them, we are on the way back to the rule of the strong hand in the shape of the bureaucratic despotism of a socialistic organization, and then of the military despotism which must follow it; if, indeed, some social crash does not bring this last upon us more quickly.

Believers in American institutions will read such language with pain; for Herbert Spencer, though educated in a foreign environment, and taught the principles of excessive government from his infancy, was a large enough man to appreciate and believe in the peculiar features of American society; and the declaration sounds like a recantation of faith, if not an acceptance of the tenets of what is called strong government. Unquestionably, Herbert Spencer voices the opinions of many men in England. The tendency to revive the spirit of feudal institutions under the name of county councils, or what not, has been generally observed; and there are doubtless many persons in England who think that the movement will greatly improve the future prospects of the Prince of Wales. It will without doubt. But how many men have we in the United States who are learning to feel in their hearts that the reluctantly changed opinions of Herbert Spencer must be also their opinions?

The social disorders incidental to strikes in this country are, of course, the cause of the changed opinions of Herbert Spencer. He has observed such events as those which culminated in the almost open battles of East Tennessee, the murderous affray at Homestead, the anarchy at Cripple Creek, and the general lawlessness of the recent coal strike, involving nearly 200,000 miners; and we can readily understand why it should be thought in Europe that the remedy against events of the kind is to be found only in the use of those repressive agencies which are believed, in European countries, to be most effective. Strong government is there thought to mean the control of both the purse and the sword ; and as the purse in recent years has been slipping further and further away from political control, the aim is to get it back through machinery that will make the laboring man a dependent upon government. Hence the state railways on the continent of Europe, and the county council movement, with state management of the railways also in contemplation, in England.

In the United States, however, the situation is entirely different. We have never held that the control of either the purse or the sword makes what we call *strong* government, though it may be admitted to make *repressive* government. We have held, on the contrary, from the beginning, that it was an element of weakness ; so much so that a large standing army is expressly inhibited, and every power delegated to congress by the federal constitution shows that it was intended to put the corrupting influences of the purse as far away as possible. But have we not a strong government in the United States?

Where in history can we find such a magnificent example of the strength of a political constitution as was offered by our civil war? Both sides in that momentous struggle claimed that they were contending for the constitution ; and after a four years' war, involving the services of three millions of men and the sacrifice of many thousand millions of dollars in money, the conflict ended with not a dot or letter affecting the organic features of the constitution changed. The very combatants in that war, when captured by the enemy, set themselves directly to debating constitutional questions with their captors, each striving to appear most loyal to the government, and, finally, after nearly thirty years of peace and unexampled prosperity, following upon the war, we find ourselves still living together under the original contract. Then what is the nature of this constitution which shows such remarkable vitality? Unless it represents a league of independent nations and not a government it must rest upon some general principles which have only to be universally observed to make us entirely secure of the future.

The constitution of the United States designates clearly the powers delegated to congress ; and then, to make certain that there shall be no doubt as to the purpose of its authors, the body of the instrument is supplemented by the amendment that follows :

> ARTICLE X. The powers not delegated to the United States by the
> nor prohibited by it to the states, are reserved to the states respectively, or

The purpose of this amendment is clear. It was not to p
self-government only, but *to define and limit political auth*

it was this definition and limitation, which, incomparably more than the Declaration of Independence, gave to this country its freedom. The Declaration of Independence might have led to only the transfer of allegiance from one despot to another; but in the limitation of political powers the despot—whether as an individual or a congress—was made impossible.

Well, we have prospered under the system that we inherited as no other people have ever prospered. Violations of the constitution there have been. The municipality, using the word as a designation of the political organization of cities, was an evolution of feudalism transplanted to this continent, and with its industrial functions it has been a thorn in our side from the beginning. It was planned originally to enable the crown to tax and govern an element of the population in England that was growing into a condition of spontaneous freedom, and it always represented an incongruity in the American system. The states, too, have sometimes forgotten their obligation to observe the principles of the federal constitution. The Erie canal, that much-vaunted but dirty ditch, smelling more offensively than the skull which Hamlet studied, with all sorts of political corruption, was built by the state of New York, and it has deprived the people of the state of at least three of the half-dozen railways which they might long since have had between the city of New York and Buffalo had no political monopoly been erected in the way. But these are exceptional examples. The rule has restricted government to the duties of government; and the results in a hundred years are almost startling. Poor men from all quarters flock here by the hundreds of thousands annually simply because they are better able to find employment in a country which exalts the individual and represses the state than in countries that exalt the state and repress the individual. Yet, our constitution is still threatened. Why, we have college professors teaching the descendants of Thomas Jefferson in books that transporting passengers on the railways is a governing function—or "a function of government"—which possibly does not mean quite the same thing to some present-day minds.

The first cause for the prevailing manifestations of dissatisfaction with our political system is of course ignorance. When Coxey marched to Washington to demand that congress set his battalions at work on country roads, he simply did not know that he was asking for something not among the duties to which congress is restricted by the federal constitution. This was ignorance. But when the New York Chamber of Commerce resolves to cripple an industrial enterprise in New York by forcing the city into the transportation of passengers in competition with a company of citizens chartered by the state, and holding vested rights derived from the state, we are bound, by courtesy at least, to say that it is not ignorance.

It is undoubtedly true that the social disorders originating in strikes, of which the last ten years have been unusually prolific, are convincing many persons, even in this country, that the boundaries of political authority need enlarging. The man of fortune does not fear government; but he does fear the mob, and he might be willing to sacrifice some of his liberties and opportunities to be more secure. Hence the curious phenomenon of a portion of the two extremes of society, antagonistic as they are sometimes thought to be in everything else, working together for a common end. The workman, captivated by that will-o'-the-wisp known as universal suffrage, thinks that he can control the government against the capitalist, while the man of fortune believes that he will be in less danger of seeing his windows broken if he is surrounded by an army of tipstaves and other government officials.

It is to be hoped, however, that the danger springing from the operation of these two forces is not so great as it seems at the moment. The workmen of this country are not in any considerable numbers adherents of the crank notions advocated in the name of socialism. They are hard-headed, practical men who feel that, under the control of either an employer or a slave-driver, they must earn their living by the labor of their hands, and they are willing to accept the employer. But here is their difficulty. They are not largely men trained in either the science of government or the laws of political economy; and when dissatisfied with the best terms that can be offered under market conditions, they are inclined to appeal to the government, which they think they control, to help them knock out the capitalist. But in this case their control ends when they have reached the demagogue, and they will find this out in the end. Statesmen know that they cannot help them without enslaving them; and they are not willing to invite a civil war which, sooner or later, would certainly follow any attempt at putting them in gyves.

But what shall be said of this other force so ready to meet the workman half-way? The members of the New York Chamber of Commerce have determined that the city of New York shall engage in the transportation of passengers in competition with citizens like themselves trying to conduct a reasonably profitable operation. This body of tradesmen must have seen a new light. "Yes," possibly will respond some of the members, "we have seen a new light. The police of a city that owns a railway will be better able to suppress a mob than the police of a city that owns no railway." Very well; but to still further strengthen the police would it not be best for the city to own or subsidize a general merchandise store for the benefit of the poor? Perhaps these merchants, however, will not confess to political motives. They only want improved transit. But there is not a man among them all who does not know that the company which they would cripple has been trying for ten years to improve its service, and that it has been foiled through political agencies. Will these merchants improve their prospects by hastening the day when chambers of commerce will be converted into bureaus of commerce and find their then executive offices in city halls?

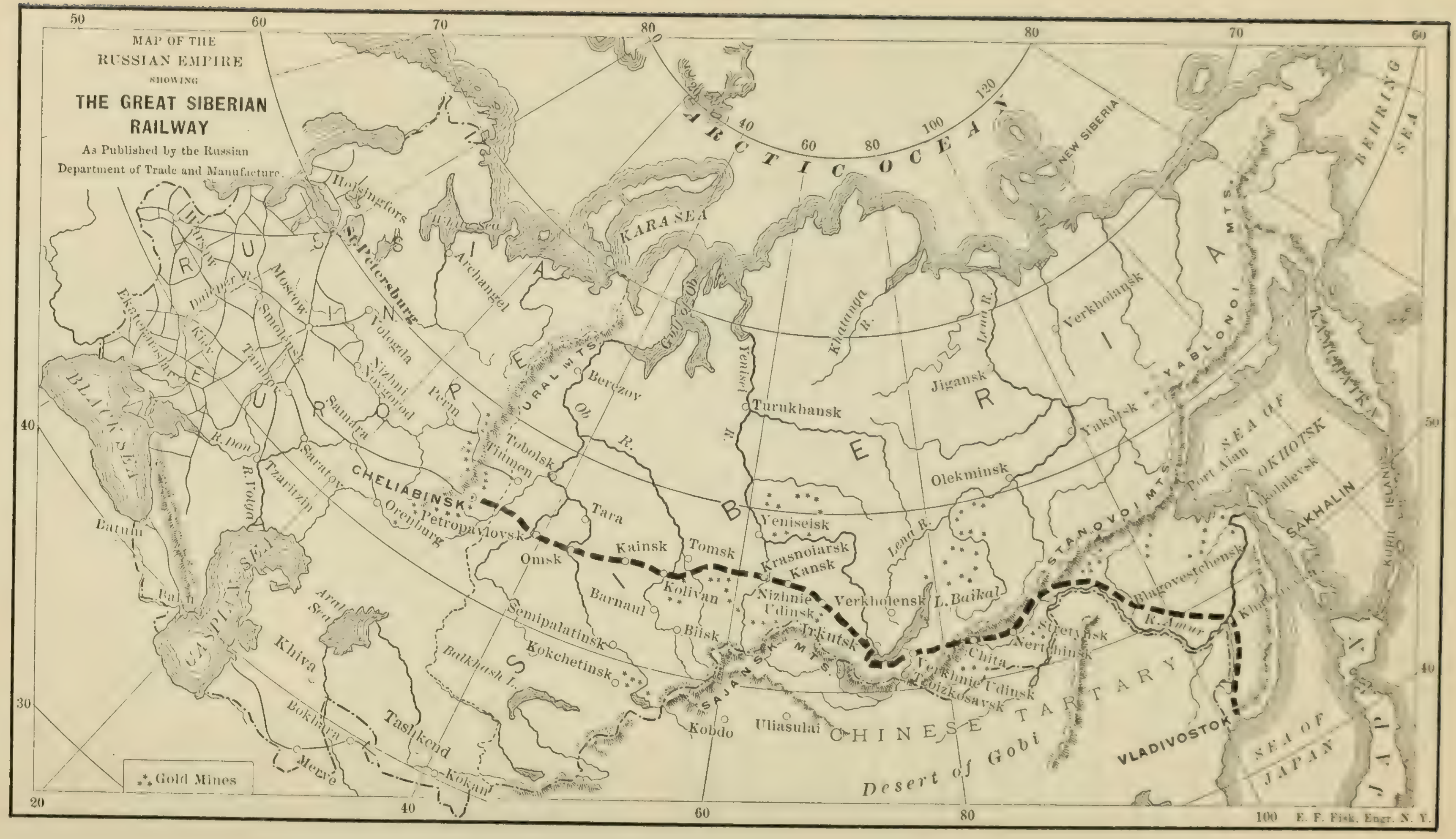
It is easy to have patience with workmen in this conspiracy against our economic interests. They have a real grievance. They seek a standard for wages that will not leave them at the mercy of employers who are so anxious to cut out their competitors that they would reduce wages, if permitted, to enable them to undersell all rivals in the market. The workmen are right, too, in their contention; for no permanent good comes to the community from a fluctuating standard of wages, however much it may sometimes help the incompetent. They are only sometimes wrong in demanding too much, and in their methods of enforcing their claims. But they themselves are the worst sufferers from these mistakes, and when their resistance does not lead to lawlessness it is not to be too severely censured. But it is hard to have patience with the merchants. They are simply revolutionists without any justification but timidity when they advocate revolutionary schemes.

Instead of a weak government, the American system gives us the strongest government on earth. Its functions are specialized and limited to the duties of government. Constitutionally, it never complicates itself with private interests, except in the performance of its police duties; and it holds itself aloof from those conflicts which private interests will continue to precipitate so long as men remain selfish and weak in judgment. This is the secret of its strength; and the little finger of our federal government, which more than the states has been observant of its true relations to the community, is stronger for the suppression of industrial disorders than the right arm of any government in Europe.

But we have terrible riots, it will be objected. True; but there are several reasons, and among them will not be found weak government. First, our people, stimulated by their greater freedom, are more energetic even in mischief-making than the people of other countries. Secondly, we have a large foreign population, habituated to see a soldier always near at hand, and when they see around them nothing of the insignia of authority they think that they can be lawless with impunity. But the third and final reason is better than the other two combined. Our people are very impatient of disorder, and when they see a mob engaged in lawlessness they labor to suppress it with the utmost diligence and energy.

No, whatever else may be needed to solve the problem of industrial discontent, we certainly do not need a stronger government; and if we did need it, we should not find it in the direction of politically-controlled industrialism—which, properly designated, is state socialism. And we are not without experience. Always a scandal, always the outcropping of some rascality, political or plundering, follows upon the undertaking of productive works by political agents. Witness "Credit Mobilier" and the Star-Route frauds in Washington; "Bill" Tweed and Tammany Hall in New York; the Philadelphia ring and the Keystone bank frauds—in short, political scandals everywhere in connection with works which government should never be permitted to undertake. Yet the public officials of this country are no worse than the officials of other countries. We think them better, indeed; but we have not the danger of revolution before our eyes, and hence do not suppress scandals for the safety of the government.

Our public officials are already too much complicated with industry and finance, and just to the degree of their complication, they lose influence in the performance of their true duties—the preservation of order and the protection of life and property.



MAP OF THE
RUSSIAN EMPIRE
SHOWING
THE GREAT SIBERIAN RAILWAY
As Published by the Russian
Department of Trade and Manufacture.

THE POLITICAL AND ECONOMIC IMPORTANCE OF THE GREAT SIBERIAN RAILWAY.

By Hermann Schönfeld, Ph. D.

AMONG the greatest achievements of this century in the way of construction of rail- and water-ways must be counted—if accomplished—the Siberian railway. The Suez canal, to a great extent, revolutionized the main lines of international traffic, and it has restored to the Mediterranean countries a share in the commerce of the world such as they had not possessed since the beginning of the modern period. The political importance of the canal is well known to every student of the present political situation of Europe. The Pacific-railway system of America actually created the western states, opening the unbounded wealth and the products of that section to the world at large. But while this railway system of the United States was destined only to serve civilizing and commercial purposes, the Canadian Pacific railway was intended, besides, to carry the military strength of England through the continent to the east against all possible emergencies that might arise, beyond the Pacific ocean, between the conflicting interests of England and Russia. When, in 1885, the Russians had routed the troops of the ameer of Afghanistan and were proceeding against Herat, the nerve shock was felt by England, not only in the endangered Indian empire, but thousands of miles farther on the slopes of the Canadian Pacific, and the fleet stationed there was directed by the foreign office in London to hold itself ready, not to proceed to the Indian waters, but to take Vladivostok, the chief naval station of Russia on the Pacific.

The great Siberian railway is intended to connect the important seaport of Vladivostok—by way of Moscow, which is some 9500 miles distant—not only with the Russian seaports on the Baltic (Riga, Reval, Libau) and the Black sea, but, like a long vital nerve, with all the ports of the European continent. More than that, it will draw the old world nearer to the new and carry the unlimited resources of the Russian empire to our own Pacific states, for direct steam-lines will necessarily follow in time, to complete the circle around the world.

The gigantic Russian empire, with an area exceeding 8,500,000 square miles, or one-sixth of the land surface of the globe, and about 110,000,000 inhabitants, is a world in itself. Its enormous resources, especially in Siberia, will enable it to compete with the greatest commercial nations of the world, when the Siberian railway is once working.

But the principal incentive for the construction of the railway by the Russian government is a strategic one, just as much as in the case of the Transcaspian railway from the Caspian sea to Samarkand, which, however, has risen to the greatest commercial importance, spreading the sphere of Russian influence to Persia, the Turkoman steppes, Afghanistan, and on the Pamir plateau.* Along its whole breadth Siberia meets the enormous Chinese empire, with its 400,000,000 inhabitants, on the borders of eastern Turkestan, Mongolia, and Manchuria. The profound respect and friendly attitude of the Russian government toward the United States, the policy of which has consciously and sometimes unconsciously for a long time realized the dangers from the same source, as well as the tacit agreement with France, which only nowadays has so energetically pushed forward its boundaries in Siam,—at such a vast sacrifice of blood and money in Tonquin and Cochinchina,—shows clearly that Russia understands very well the necessity of a triple alliance of its own against the Mongolian world behind which England stands. History may repeat itself, and what a Mongolian yoke means Russia has not forgotten. It has not yet been able to free itself from all the traces of that Tartar yoke that weighed so heavily upon the Russian people from 1238-1462, and annihilated their material and political development even for centuries after their liberation.

It is very characteristic what Colonel N. A. Voloshinov, with a slight touch of irony, says before the Imperial Russian Geographical Society: "The Chinese newspapers are full of English articles that clearly prove how weak we are in our east and how advantageous it would be for China to possess our Ussuri provinces. There is no doubt that for the present China will not listen to the evil advice of those foreigners, but there is no doubt either that such conditions can not exist for any length of time. A misunderstanding, however slight, would suffice to destroy our for centuries [*sic!*] cordial relations with China. . . . The Siberian railway shall exist not to embroil us with China; on the contrary, we need it in order to strengthen our friendly relations to China for many centuries to come. When China will know our strength in the east, it will resist the temptations of those who wish ill for Russia and China alike. Besides, Vladivostok is a spicy, tempting bit for any naval power which could wound Russia on that point without any risk of being immediately punished for the outrage. As Sebastapol was in 1856 the aim of the hostile operations of our enemies, so *Vladivostok also will certainly be a similar object for our European enemies*. This must be decisive to build the great Siberian railway in order that Vladivostok may be connected with the central forces of Russia in not more than six years."

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* *From London to Bokhara and a Ride Through Persia.* By Colonel A. Le Messurier. Dedicated to Lieutenant-General Annenkoff, under whose direction the Transcaspian railway was constructed. London: 1889.

Perfect harmony exists between Russia and Japan, but the roots of that harmony lie in the common antagonism against China and in the Russian desire of controlling the insular empire in an economic way ahead of the English. Still more in China Russia has to compete with the old-established and obstinately-striven-for prestige of England. On the European boundary of Russia, on the other hand, the antagonism between that power and Germany and Austria is deeply rooted. The prospective discontinuation of the tariff-war between Russia and Germany, arising from *dira necessitas* and yet causing such bitter dissatisfaction in certain agrarian circles of Germany, is only a *provisorium* which, even if passed by the reichstag,—as is to be hoped and wished for,—will change very little the present political state of affairs of those two countries, and may be broken at any time under certain unforeseen tensions and stringencies. The very possibility of the latter must make it desirable for Russia to free herself from any absolute dependence from that side where political considerations may build an unsurmountable tariff-wall.

Thus political causes produce economic effects. Siberia, with its enormous mineral treasures and immense undeveloped products, must be opened for Russia and that country—twenty-five times the size of Germany, two-and-one-half times that of European Russia—is to become by colonization a real power, an empire in itself to feed European Russia, if necessary, to carry by rail the abundance of one part of the realm to the other, and to become a tremendous military power in the east against China and in the south against British India.

The principal impediment to traffic is the fact that even the European regions of Russia are so thinly populated, the average population being but forty-two to the square mile. Siberia,—with its immense area of 4,824,540 square miles, covering more than 25 degrees of latitude and 120 degrees of longitude, with a great variety of orographical and climatological features, with its arid deserts and frozen seas, to be sure, but also with millions and millions of acres of the most fertile soil, and immense mineral wealth,—has only 4,095,535 inhabitants, and is ready to receive many more millions of them. Strange to say, although according to statistics the proportion is 7 dessjatines* of ground to one inhabitant in European Russia against 1½ dessjatine in western Europe, still the Russian peasant has no sufficient soil to support his family with its production. This is due to various causes: division among the many heirs of one family; defective means of tilling the soil; in many portions of the empire to the queer, irrational "commune" system according to which the ground belongs to all and to none; that system of devastating the forests and abusing the soil which the Germans so adequately call *raubwirtschaft*; the concentration of the ground in a few hands so that for instance in the province (*gouvernement*) of Perm 99.8 per cent of the soil is concentrated in the hands of sixty persons. Therefore the Russian peasants, proceeding from the middle Ural, are moving slowly through south Siberia, occupying the best agricultural tracts in western and eastern Siberia. But since the ways of communication are very poor, traveling being possible only in summer, and under the most unfavorable condisions, requiring at least two summers, the colonization goes on very slowly ; yet 44,600 emigrants settled in the south of the province of Tomsk in 1882, and 95,501 persons in the Altai region in 1884-89. But those emigrants who wish to settle in the Amur region have to cross the whole of Siberia, a distance about four times that between Petersburg and Sebastopol. It is natural that 90 per cent. should not reach their destination, but settle anywhere on the way ; the few, however, who really penetrate to the Amur have needed often twelve to fourteen years for the passage ! This state of affairs makes the colonization of the east practically impossible. Consequently the balance of power between Russia and China stands at present so that Manchuria is populated with 10,000,000 Chinese, and the whole Russian coastland with less than 100,000 inhabitants. And Russia fully realizes the danger of the situation.

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*1 dessjatine—2.6997 acres.

The Siberian railway, however, will open an immense territory for emigration and we shall see there the same spectacle which the builders of our Pacific-railway system have presented to the eyes of the astonished world. If we state the distance from Cheliabinsk to Vladivostok at 7100 versts* and the territory to be colonized at 100 versts on both sides of the line, 1,420,000 square versts will be open to European Russia for colonization,—a territory of the size of Germany, Austria, Belgium, Holland, and Denmark taken together. And a beautiful, fertile country withal—the fertile black-earth prairie steppes of the Tobol and Ishim, plains covering some 25,000,000 acres, *i. e.*, a country of the size of France,—having at present only 2,000,000 inhabitants. The net of navigable streams will spread the population in all directions from the railway line along which necessarily many towns and villages will arise.

With the increased and properly-spread population, the immense mineral wealth of Siberia will be made accessible to European Russia, when the present exceedingly poor economic conditions shall be improved by the construction of the great Siberian railway. A highly-developed mining industry will grow at a rapid speed with the possibility of carrying the mineral treasures which lie untouched in the ground of

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*1 verst = 0.66269 English miles ; 1 square verst = 0.43916 square English miles.

Siberia to Russia proper and to the market centers of the world, of importing improved machinery, and, before all, skilled laborers. For, at present, the condition of the workmen in the Siberian mines is very bad, owing to insufficient food, poor lodging, and the employment of exported criminals. But even under such conditions 1,855 poods* of gold are gained in Siberia every year, and 500 poods in the Ural, or a total of 2402 in all Russia, representing 30,000,000 rubles. Only the United States, with their superior methods and free laborers, surpass the Russian exploitation by 150 per cent., and Australia by 20 per cent., although the Russian territory containing gold surpasses both America and Australia. By reason of the technical insufficiency silver-mining has been almost abandoned in Nirtshinsk and the Altai. As for the extraordinary wealth of iron and coal in the southern Ural, the governments of Tomsk, Tenessei, Irkutsk, and the Khirgise steppes,—the latter also being the "salt empire,"—I may refer the reader to "The Industries of Russia, by the Ministry of Finance," translated by Mr. John Martin Crawford.† Even precious stones are frequent in the Amur domain, and the lapis lazuli in the Baikal mountains. Yet the exploitation stands in no proportion to the actual mineral wealth for the reasons stated above.

But all these disadvantages will be cancelled, labor and freight will become cheap and plentiful, capital will be invested in Siberian mines, and many millions, incalculable at present, which are hidden in the Siberian ground, will flow into the Russian treasury and among the people. The net of Siberian streams will become connected with the Volga, and the tools, implements, and machines necessary for Siberian agriculture and mining will be easily imported. Heretofore these articles bought on the markets of Nishni-Novgorod and Irbid trebled in price before arriving at their place of destination. The result was that goods of that kind had to be imported across the Pacific from America and England, by way of Vladivostok, to the amount of 7,000,000 rubles every year. But even this source was cut off by closing the free port by a very high tariff, so that the Siberian consumer has to do without the most necessary articles of manufacture. The great Siberian railway will therefore not only carry the metallic and other treasures of Siberia to European Russia, but also provide the Siberian population with the necessaries of life and comfort, with everything apt to make them civilized and wealthy. The extremely low figure of the Russian-Siberian trade, amounting to not more than 50,000,000 rubles yearly, will surely at once rise to a normal figure and spread evenly the products of one province to the others, do away with the present anomalous condition under which the prices of certain goods vary about 300 per cent. in different provinces, and grain is sold at mock figures in one province while there is an actual famine in others.

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*1 pood = 34¼ English pounds.

† Mentioned under "Current Technical Literature," in this issue of the Magazine.

Yet, this is not all. Russia's entire international commercial intercourse will be changed for the better. Although Russia has a very large sea-coast, yet the enormous length of the northern ice-sea is hardly of any avail for international traffic, and the Baltic is frozen at least five months during the year. The entrance to and exit from the Black sea can be easily blocked by England and Turkey in critical times. Thus it is a life question for Russia to extend the usefulness of the broad Pacific coast by connecting ways of communication and to build up in an artificial way a properly-distributed net of railroads. Although a great deal has been done in that direction, the Russian railway-system is still very scant. Only after the Crimean war did Russian statesmen begin to realize that rapid transit was a necessity for a first-rate power, especially if it was a military power. In 1891, Russia had a railway net of but 32,372 kilometers, while Germany, whose size is only a small fraction of Russia ($\frac{1}{25}$), had more than 42,000 kilometers, not to speak of the United States, with their enormous system of railways. Nor is the net of the navigable streams sufficient for Russian commerce, these streams being navigable only in spring and autumn, the water drying out in summer and freezing during the very long winter. Besides, the Caspian sea, with only 20 per cent. of the traffic, absorbs 40 per cent. of the rivers; the Black sea, with 55 per cent. of the total Russian traffic, receives only 27 per cent. of the waterways; the Baltic, with 23 per cent. of the traffic, receives only 15 per cent. of the rivers.* In Asiatic Russia the huge streams, the Ob, Yenissey, and Lena are practically of no account except in their upper course and its tributaries. Thus, owing to the immense unconnected distances of the thinly-populated regions producing such a variety of products, these latter, as well as the products of industry,—which is limited to but 20 of the 50 provinces,—will become valuable only by a cheap, rapid distribution in all directions. To accomplish this end the construction of the great Siberian railway has been undertaken. It is also rather sure that a dislocation of the English trade will take place. At present the English are the principal mediators of commerce between Europe and Hindustan, China, and Japan. But when the Siberian railway will be able to carry the goods of all Europe, as well as of the whole east, from the western Russian boundary to Vladivostok in twelve or thirteen days, instead of six or eight weeks as it stands now, then it is surely to be expected that a large percentage of those costly exports from China, tea and silk, will take their way to Europe by the Siberian railway instead of being shipped on English steamers via the Suez canal.

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* Some of the statistical data are taken from Mr. N. Syrkin's able article in *Vierteljahrschrift für Volkswirtschaft, Politik u. Kulturgeschichte.* Berlin: 1893.

In 1890, the export from China amounted to £7,848,000 worth of silk and £6,916,000 worth of tea. Of the 24,878 tons exported from Chinese seaports, 16,098 tons—*i. e.*, more than 64 per cent.—were shipped by English vessels. But England herself, with her rich tea-plantations in India and Ceylon, is China's most dangerous rival. Of course, England imports to Europe only so much from China as she can sell beyond the supply that can be obtained from her own colonies. Thus the tea export from China fell from 74,235,000 pounds in 1891 to 60,064,000 pounds in 1892, the deficit amounting to 14,171,000 pounds. It is perfectly safe to say that with the construction of the Siberian railway there will be a revival of the tea export from China and that all Europe will be provided with Chinese tea by that railway. And why should not also Chinese silk be exported in the same way, the freight of that light, valuable commodity being very low? Of course, a reasonable tariff system and commercial *modus vivendi* will have to be found and an equitable *do ut des* policy to be inaugurated to raise the commerce between Russia and China, which stands now at the ridiculously low figure of 18,000,000 rubles. How much Germany, France, and England will lose is self-evident, for that neighboring states with a little good will can defeat distant competitors is almost a political-economic maxim and in this special case proven by the extraordinary rise of Japanese mining and manufacturing products used in the Chinese empire.

As for the topographical and technical conditions of the great Siberian railway, I may again refer the reader to the "Industries of Russia," (Vol. V, chapter XVI.) Only so much may be said that the length of the railway will surpass our own Pacific railway from New York to San Francisco, having a length of 5500 kilometers compared with 4000 kilometers. The technical difficulties will be by far more difficult to overcome than those in the construction of the American Pacific-railway system have been, except in the case of the Canadian Pacific, which offered somewhat similar difficulties.

With the accomplishment of this stupendous work Russia will enter among those nations which give this century its brilliancy and glory for having raised the technical and commercial progress of the human race to an almost incredible standard. Two undertakings of similar dimensions are still left to be accomplished,—*i. e.*, conducting a railway through the whole length of the western hemisphere and the completion of the Panama canal. Will the glory of these two great works fall to the lot of the United States?

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QUARRYING METHODS OF THE ANCIENTS.

By W. F. Durfee, M. Am. Soc. M. E.

THE methods of obtaining stone for general building purposes by the ancients have become known to us by the explorations which have been made in the early Egyptian quarries, and in what may with propriety be called stone-mines. Of the latter, the workings at Tourah and Massourah, in the Mokattan range of hills, south of Cairo, from which the whole of the limestone used in the pyramids was obtained, are good examples. These stone-mines were opened and worked in this way :

A gallery about twenty feet wide and high was run from the face of a cliff, in a carefully-selected stratum of rock (in this case a fine-grained nummulitic limestone) deep into the heart of the mountain. In driving this gallery the workmen excavated a recess or "heading" at its top, high enough for them to work in, and of the full width of the gallery, and they carried this heading far enough forward to enable them to cut a groove vertically downward behind the first block of stone that was to be taken out. While this was being done, other workmen were cutting vertical grooves on each side of the gallery from the heading to the gallery floor. At the same time a groove was cut at the level of the floor connecting the two flanking grooves. The mass of stone bounded by the three grooves and the heading was then divided into such sized blocks as was desired, the upper block being first removed, and as soon as it was out of the way the heading was pushed forward. After the entrance gallery had advanced a sufficient distance from the face of the cliff, another gallery was opened at right angles to it and extended on either hand ; and at the distance of twenty feet another gallery was driven parallel to the last, and still other galleries parallel with the first, until finally, by a rectangular system of intersecting galleries, a very large space in the interior of the mountain was converted into an enormous hall, the roof of which was supported by pillars twenty feet square, standing twenty feet apart.

The stone excavated was all removed through the entrance of the first gallery, which was often at a considerable height above the base of the cliff, a ramp having been constructed from the entrance of the workings down which the stone was dragged on sledges by men or oxen. Figure 1 is a distant view of the Mokattan range of hills over the village of Tourah, and Figure 2 is a view of the Tourah quarries seen from the mouth of a drift. The ancient quarry-men, in driving galleries, were accustomed to trim the roof to the required level, and on

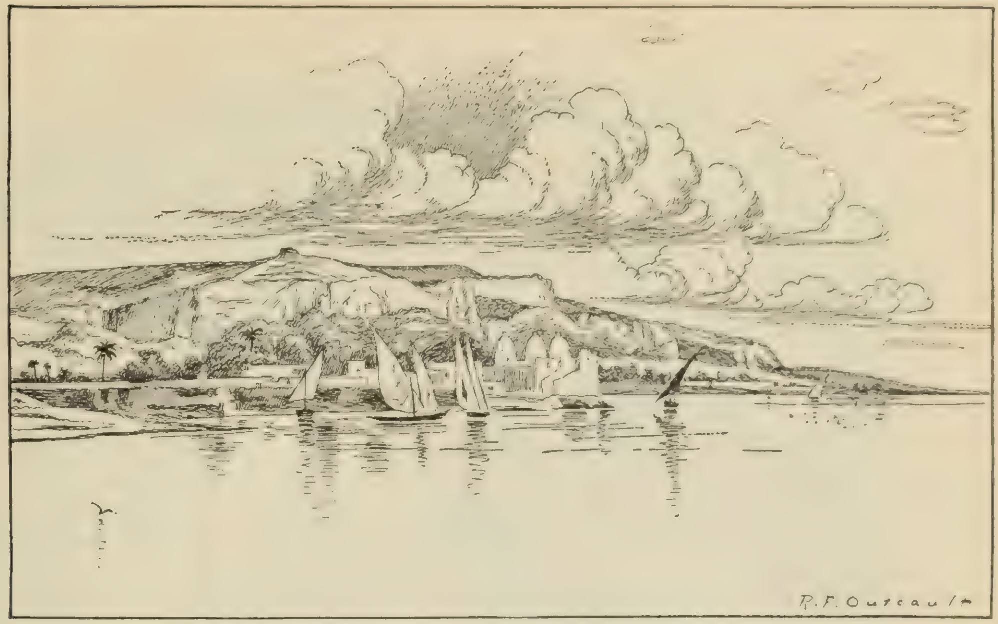


FIG. I—DISTANT VIEW OF TOURAH.

it was then drawn a center line in red, and the sides of the gallery were then trimmed vertically in planes parallel to this center line. The open quarries of Egypt are vast *intaglios,* cut deep in the living rock by a skill whose evidences in tool-marks and drill-holes, in the selection of good materials, and the rejection of bad, remain after the lapse of more than three thousand years to excite our wonder that such achievements were possible without the aid of power-drills or explosives.

Figure 3 is a view of an angle of an ancient open quarry discovered

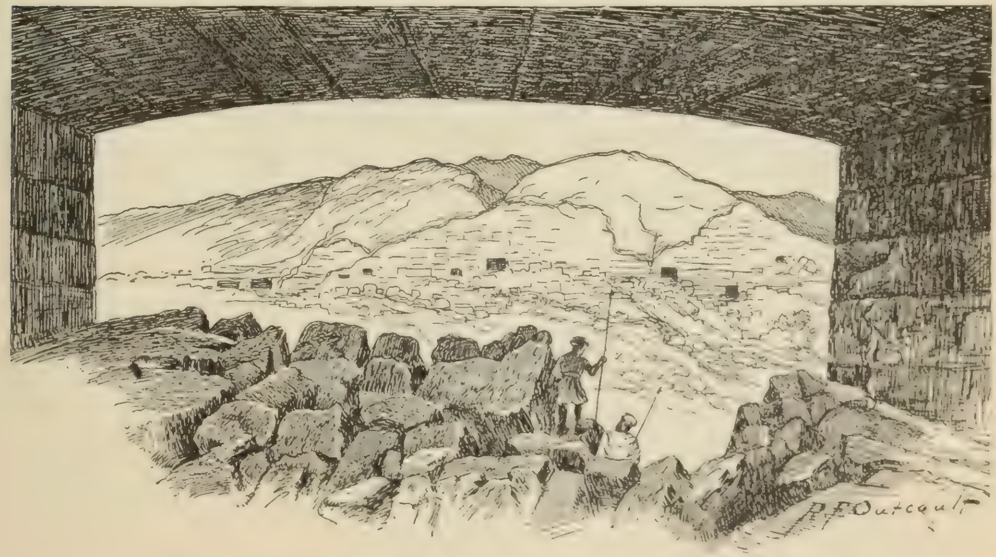


FIG. 2—QUARRIES OF TOURAH—LOOKING OUT OF A DRIFT.

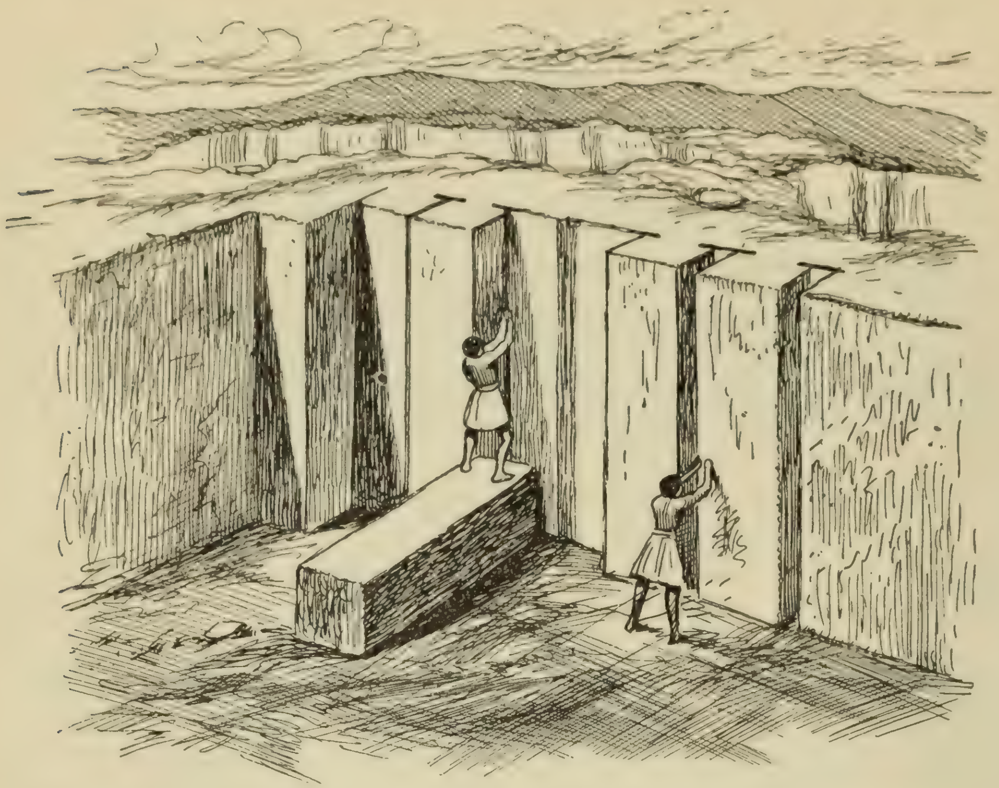


FIG. 3—ANCIENT OPEN QUARRIES NEAR JERUSALEM.

near Jerusalem and illustrates the method used by the ancients for quarrying large masses by cutting vertical grooves along their sides. Evidence of a similar method of working is seen in the quarries of Syene.

Granite in large masses was always obtained by the Egyptians from open quarries, the most famous of which were at Syene (hence the word "syenite," designating a variety of granite composed of quartz, hornblende and feldspar) in upper Egypt, near the first cataract of the Nile. The methods adopted for the horizontal quarrying of granite blocks of ordinary size was to cut a narrow groove two or three inches deep parallel with a vertical face of rock at such distance as the width of the desired stone required ; in the bottom of this groove rectangular holes were made, about two inches long, one inch wide, and two inches deep ; these were usually placed about four inches apart ; dry wooden plugs were then driven tightly into these holes, and the spaces between them in the groove first mentioned filled with water ; and the expansion of the plugs as they absorbed this water split the stone in the line of the holes. No more uniform and simple application of sufficient force for the purpose could possibly have been devised.

The Egyptian method of quarrying out an obelisk from a granite

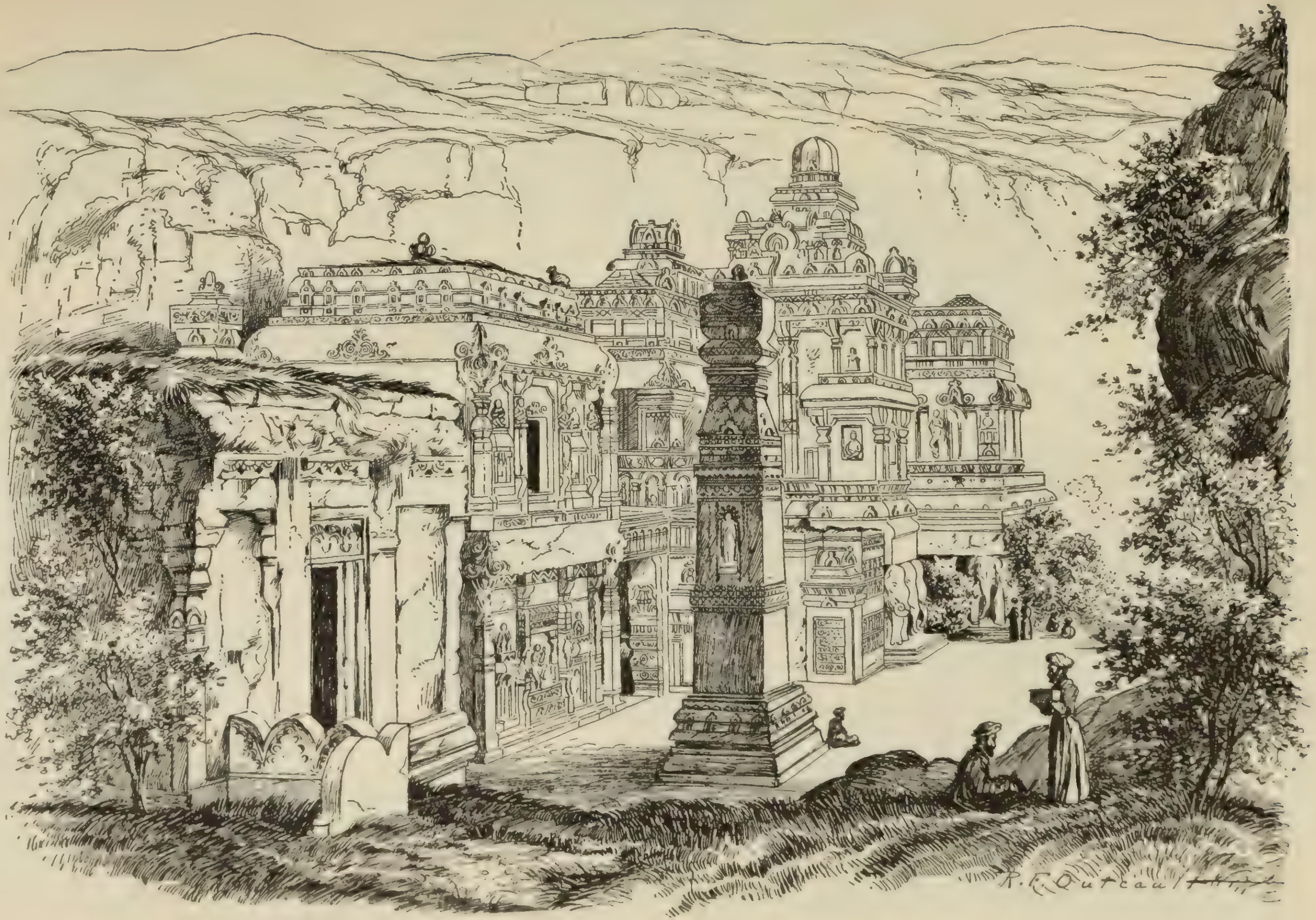


FIG. 4—ROCK-CUT MONOLITHIC "KYLAS" TEMPLE, AT ELLORA, INDIA.

[This work is supposed to have been executed in the ninth century. The rock is granite, and the excavation or quarry in which that wonderful structure stands is about 150′ × 270′. The arrangement of the interior of the temple is quite intricate. The height is upwards of 100′.]

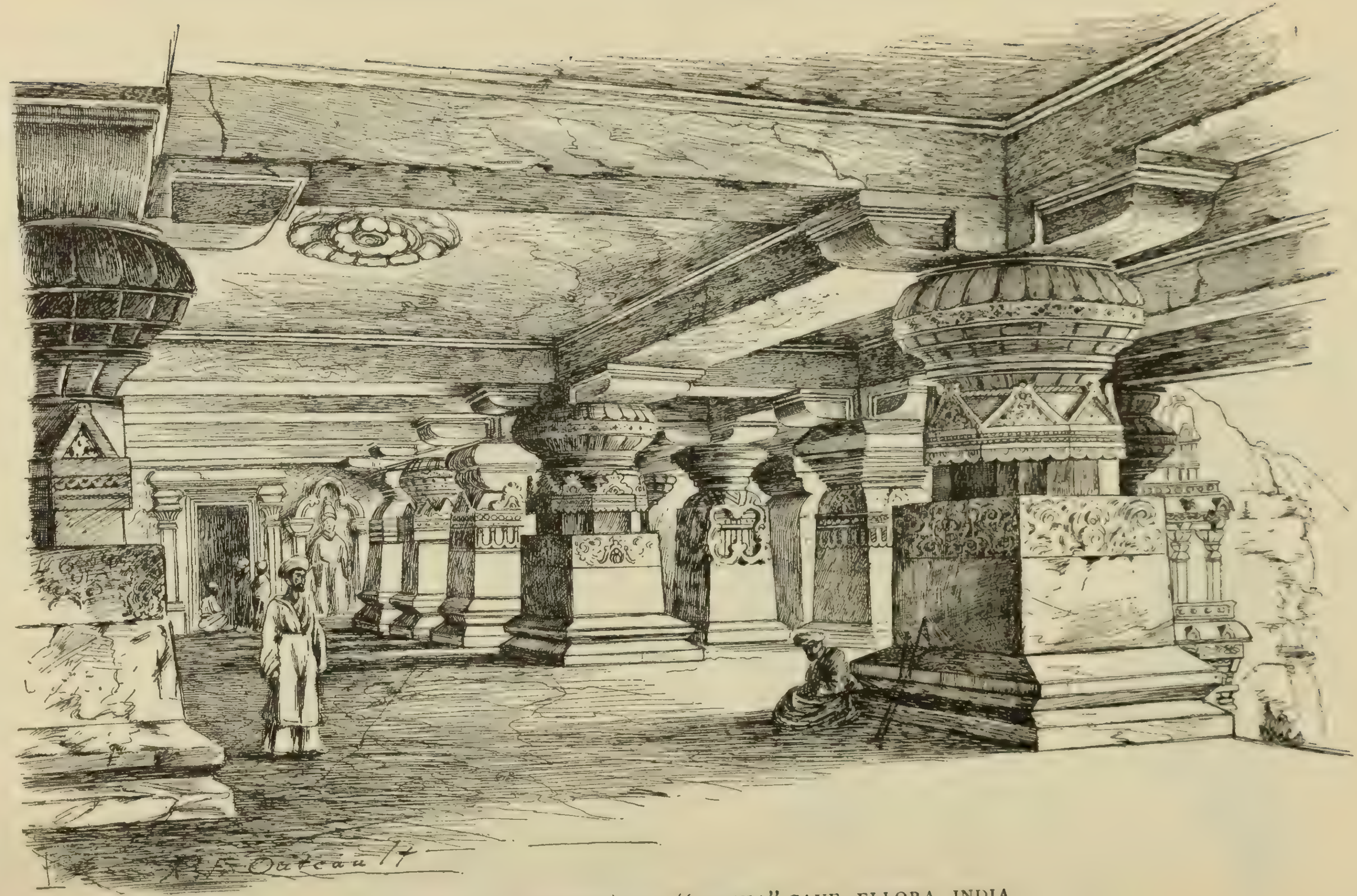


FIG. 5—ROCK (GRANITE)-CUT "LANKA" CAVE, ELLORA, INDIA.

[Date about the Tenth Century A. D.]

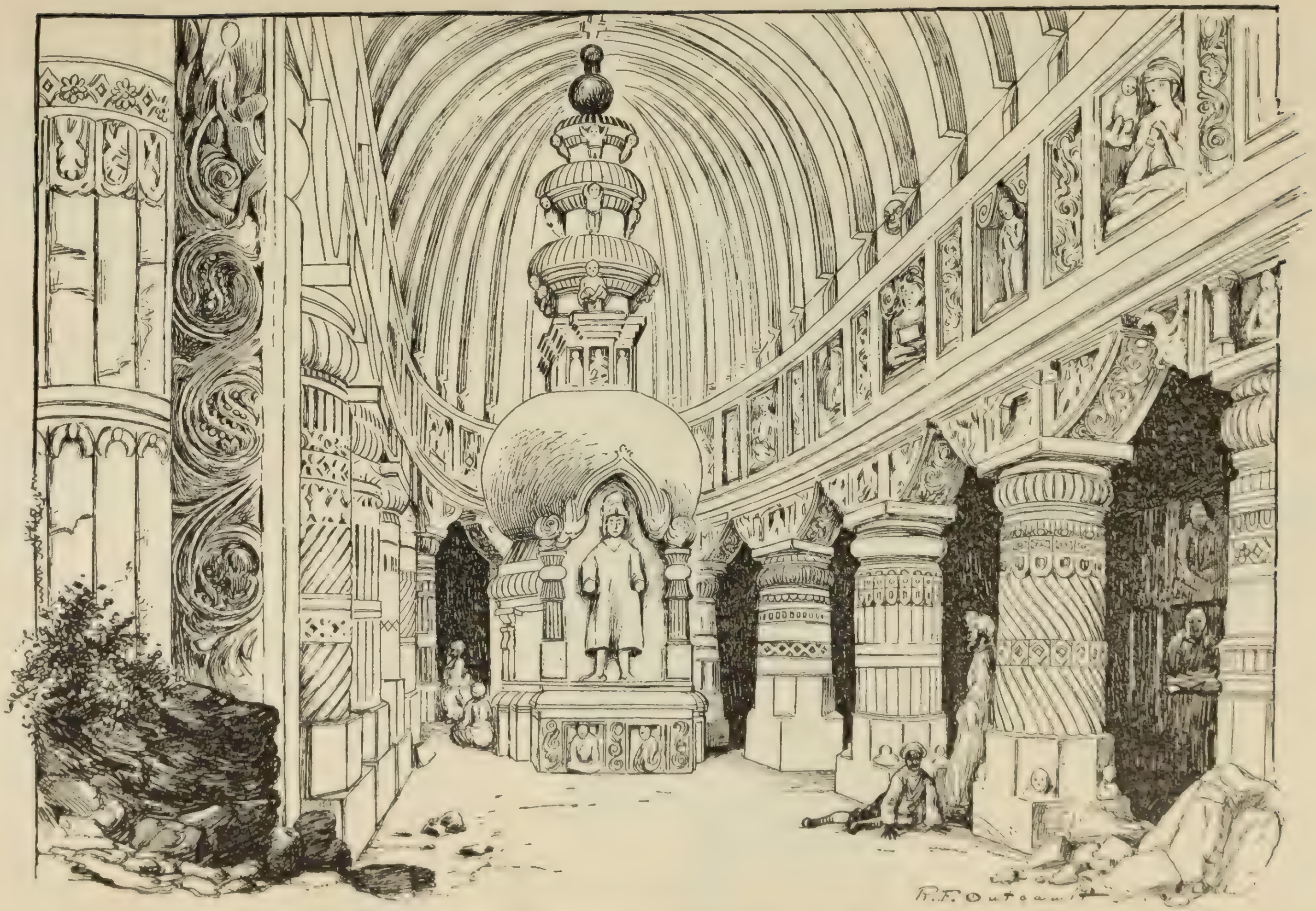


FIG. 6—BUDDHIST "CHAITYA" CAVE OR CAVE TEMPLE AT AJUNTA, INDIA—ABOUT 200 B. C.

[The dimensions are 46′ × 28′. The roof and all the details are cut out of the solid rock. On the front of the "dagoba" or shrine is cut a statue of Buddha. The cross on the roof above the shrine is not a symbolical cross, but merely an intersection of the ribs which has been made too prominent by the engraver.]

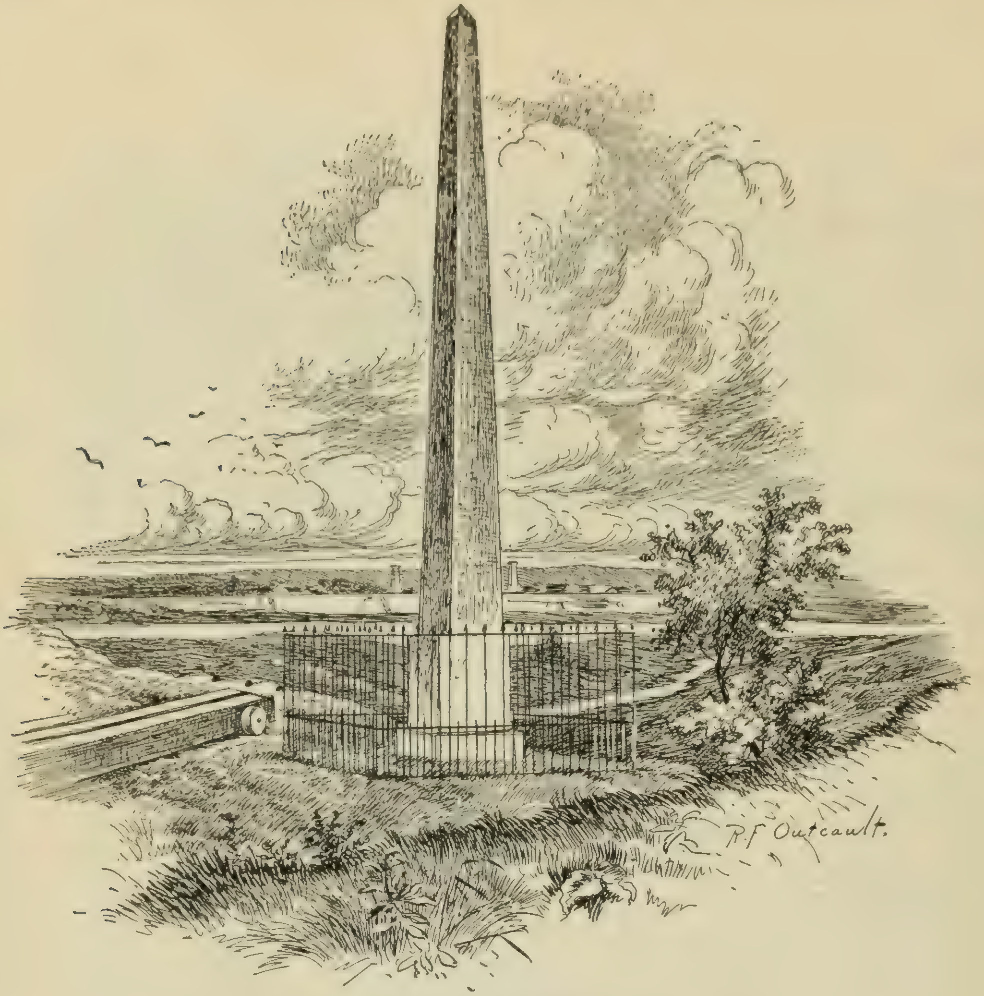

R.F. Outcault.

FIG. 7—GRANITE OBELISK AT SERINGAPATAM, INDIA.

[Erected in memory of Josiah Webbe, Esq., about the year 1815. All the work was done by Hindu workmen by their customary methods. At the left of the picture is shown the low timber truck on which the shaft of the obelisk was conveyed from the quarry.]

ledge is well illustrated by the enormous partially-finished monolith still remaining in the quarry at Syene. This obelisk would have been, if completed (it is still attached to the floor of the quarry), larger than any now known. According to Wilkinson it measures 95′ long and is 11′ 1½″ square at its base, and weighs 1,540,000 pounds, or 770 net tons. It was brought to its present condition by carefully excavating the rock on either side of it, dressing the sides and upper surface to their intended form, and running a groove along each side next to the floor of the quarry, preparatory to the introduction of wooden plugs for separating it from the bed-rock in the manner already stated. But these plugs have never been fashioned, and the vast mass has told the succeeding generations, for unknown thousands of years, of the technical methods of men who wrought long prior to the time when "Solomon's builders and Hiram's builders and stone-squarers" gave dimensions and beauty to the silently-assembled details of the grand temple of the wise king.

Hindustan abounds in examples of rock-cut or quarried temples and shrines, of which I have selected three as illustrations of the marvelous skill of the ancient Hindus in the arts of quarrying and ornamental working of stone. Figure 4 is a view of the "Kylas" temple at Ellora. This is cut out of the solid granite rock with wonderful skill and elaboration of detail. The quadrangular pit in which this temple stands has on its sides and rear end (its front being open) rock-cut colonnades and cloisters, the columns of which support the perpendicular rock above. This temple is supposed to have been quarried out to commemorate the triumph of the Sivites over the Buddhist faith. Figure 5 is another excellent example of Hindu quarrying. This rock-cut cave is in the immediate vicinity of the "Kylas," a portion of which can be seen at the right of the right hand columnar pier. Figure 6 is, according to Furgusson, "one of the most perfect, though far from being one of the most splendid, of the 'Chaitya' caves in India. In this instance every detail is cut in the solid rock, and there does not appear to have been a single wooden ornament on any part, so that we now see the cave nearly as it was left when first excavated." Similar work, though on a less elaborate plan, was executed at Petra, a rock-cut city, of Arabia Petræa, about half-way between the south end of the Dead sea and the head of the Gulf of Akabah. The rock-cut edifices in Petra are supposed to date about the second and third centuries of our era.

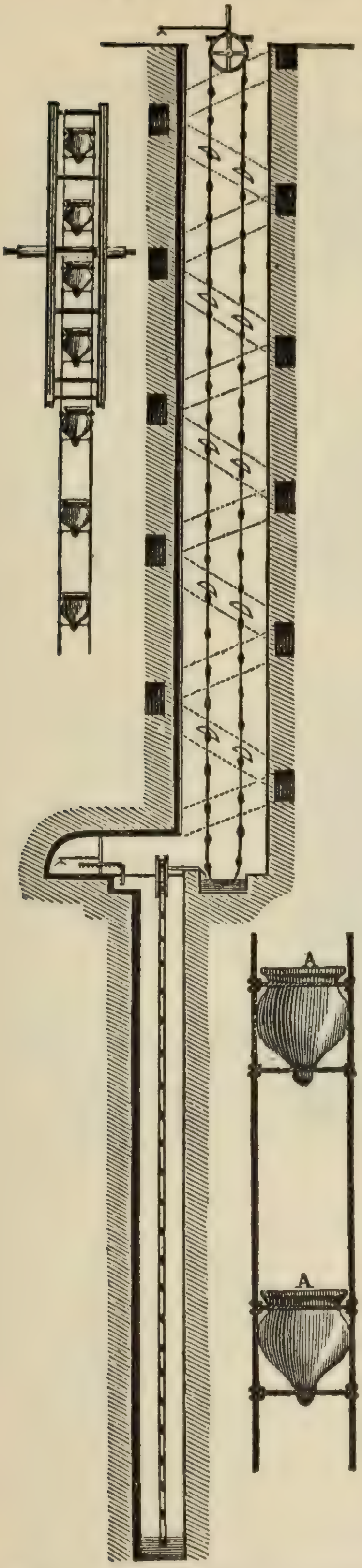
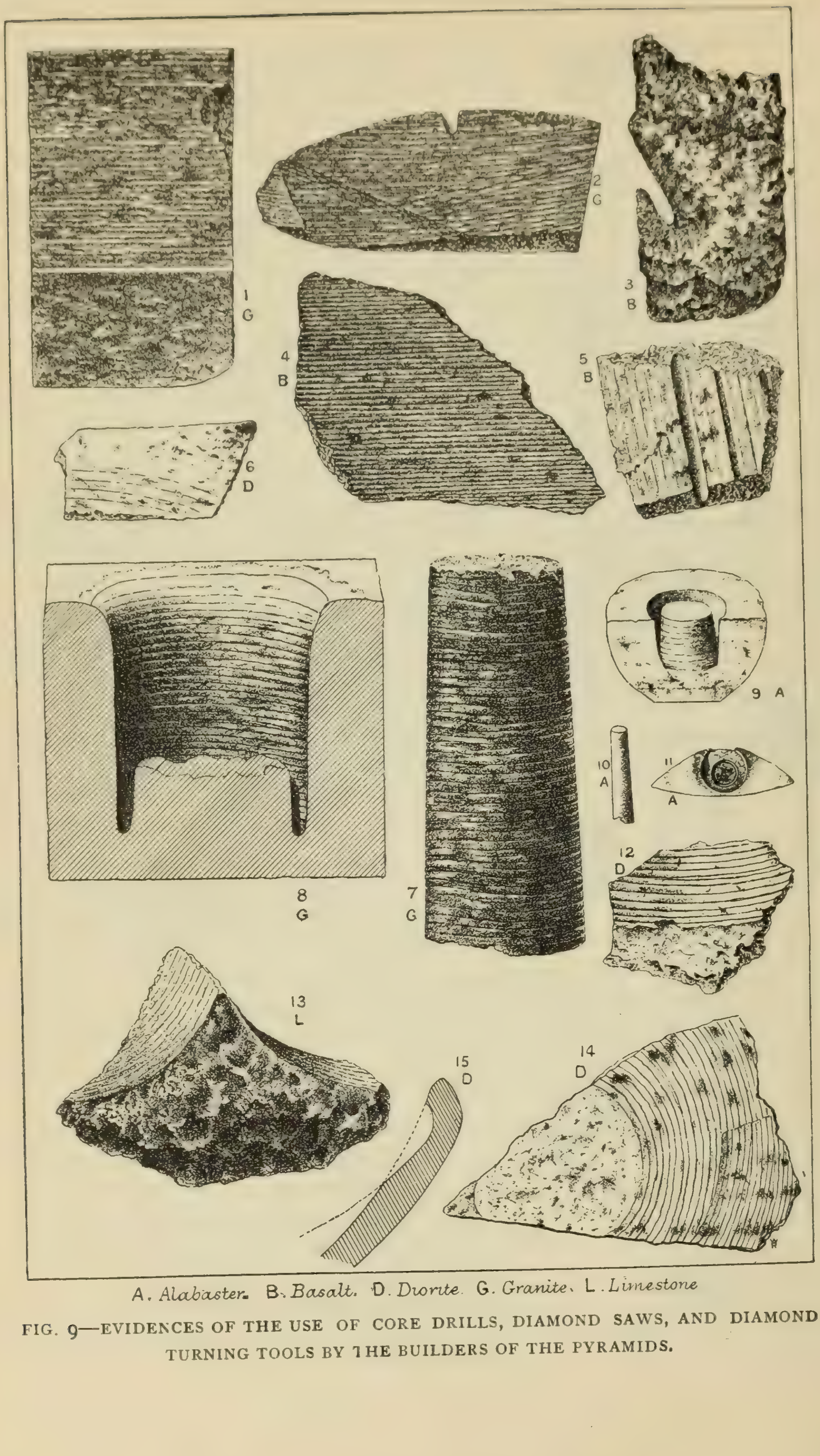


FIG. 8—JOSEPH'S WELL IN THE CITADEL AT CAIRO.

NOTE.—The detail at the left of the cut is the lantern wheel around which buckets traveled; at the right are shown the earthen buckets.



A. *Alabaster.* B. *Basalt.* D. *Diorite.* G. *Granite.* L. *Limestone*

FIG. 9—EVIDENCES OF THE USE OF CORE DRILLS, DIAMOND SAWS, AND DIAMOND TURNING TOOLS BY THE BUILDERS OF THE PYRAMIDS.

Of the methods employed from the earliest times in Hindustan for quarrying large masses of granite, we are given an insight by the work done (entirely by native workmen) in the erection of an obelisk at Seringapatam in the early years of the present century. The stone quarried for this obelisk was 84′ in length, but the completed shaft was somewhat shorter, a small piece having been accidentally broken off in handling the rough stone. It was 6′ square at the base when finished, and was placed upon a plinth of a single block of granite 7′ square and 9′ high, in the top of which was formed a socket 6′ square and 3″ deep, to receive the base of the obelisk. Figure 7 is a view of this obelisk.

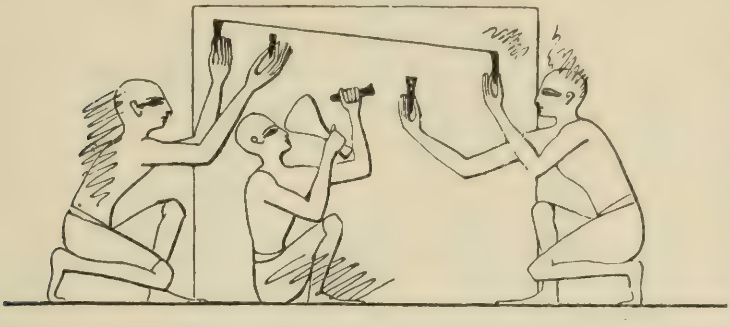


FIG. 10.

Colonel Wilkes says: "Although I anxiously watched the progress of this interesting work, I as anxiously left it to be exclusively Indian, and the design of the obelisk was the only aid afforded by any European to the native workmen."

Colonel Wilkes gives the following description of one of the methods adopted in the quarrying of granite at the quarries of Seringapatam, and states that it was used in the case of the above-named obelisk:

"The spot being determined, a line is marked along the direction of the intended separation, and a groove about 2″ wide and deep is cut with chisels; or, if the stratum be thin, holes of the same dimensions, at 1½′ or 2′ intervals, are cut along the line. In either case, all being ready, a workman with a small chisel is placed at each hole or interval, and with small iron mallets the line of men keep beating on the chisels, but not with violence, from left to right or from right

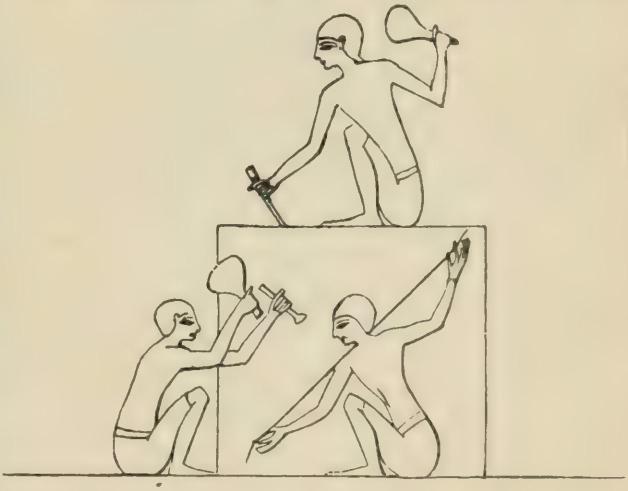


FIG. 11.

to left. This operation, as they say, is sometimes continued for two or three days before the separation is effected."

Sir J. F. Herschell describes another method which is sometimes used at the same quarries, but which "does not produce so clean a fracture as the first by beating. . . . The workman, having found a portion of the rock sufficiently extensive, and situated near the edge of the part already quarried, lays bare the upper surface, and marks on it a line in the direction of the intended separation, along which a groove is cut with a chisel, about a couple of inches in depth. Above this groove a narrow line of fire is then kindled and maintained till the rock below is thoroughly heated, immediately on which a line of men and women, each provided with a pot full of cold water, suddenly sweep off the ashes and pour the water into the heated groove, when the rock at once splits." This brings to mind the method attributed to Hannibal of splitting rocks during his passage of the Alps; and it has been suggested that his use of vinegar instead of water may have been found advantageous as applied to certain kinds of rocks.

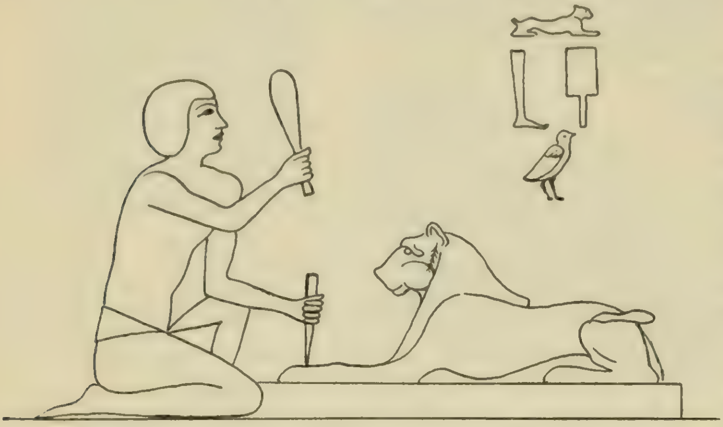


FIG. 12.

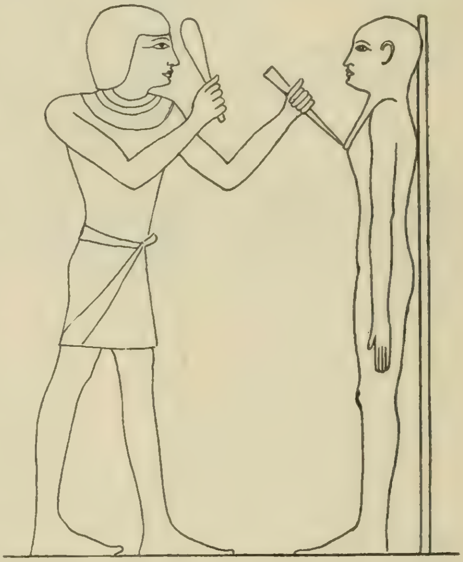


FIG. 13.

In sinking shafts in rock, the work of the ancient Egyptians is quite equal to that of any succeeding race. Perhaps the most remarkable shaft known is that of Joseph's well at Cairo, shown in an engraving on another page. The upper portion of this remarkable work is rectangular in cross-section, measuring 24′ × 18′, and is excavated of these dimensions through solid rock to the depth of 165′, at which level it is enlarged into a capacious chamber in the floor of which is formed a tank to receive the water elevated from below. On one side of this tank, which is immediately at the bottom of the upper shaft, another shaft, 15′ × 9′, but not in a line with the first, is sunk 130 feet lower, where the rock ceases, and a stratum of gravel is found which furnishes the supply of water, which is raised into the tank at the bottom of the upper shaft by machinery propelled by horses or oxen working within the chamber. These animals reach this chamber by descending a series of inclined drifts which pass around the upper shaft in a manner similar to what is known as a "spiral stair." These drifts are separated from the interior of the shaft by a wall of rock not more than seven inches thick, and segmental apertures are cut through it to light the drifts from the shaft. These drifts are 6′ 4″ wide, and 7′ 2″ high. The lower shaft is also provided with an inclined path cut out of its sides and descending to the water, but there is no partition between it and the well. Figure 8 is a vertical section of this remarkable work.

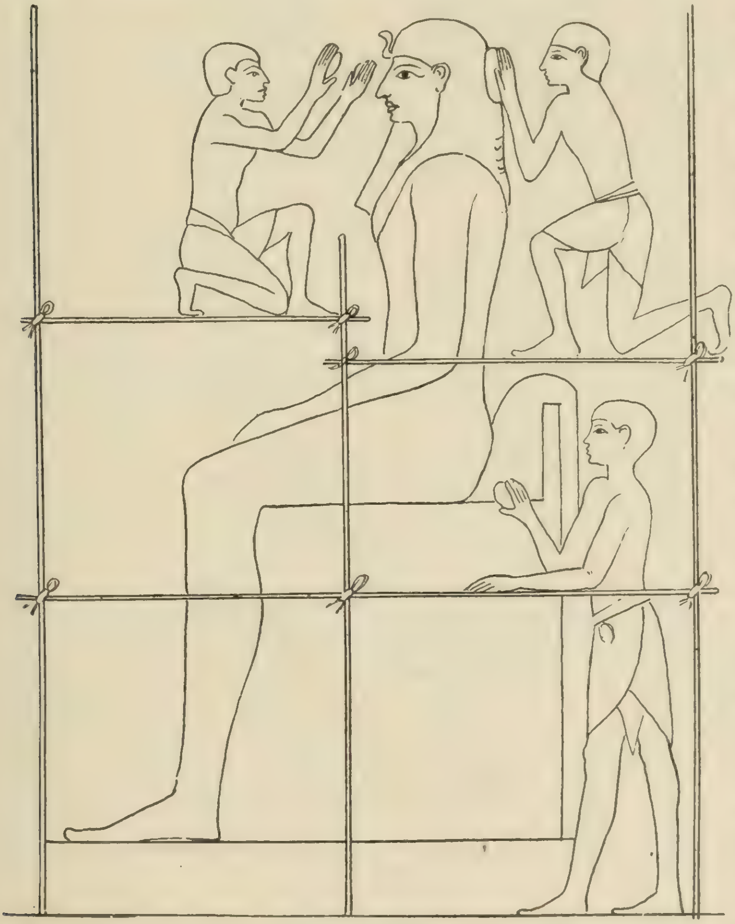


FIG. 14.

There has been a great deal of speculation relative to the means by which the Egyptian engineers carried the first shaft down, preserved the angle of the descending drifts, and maintained the uniform thickness of the thin partition separating the drifts from the shaft. Without doubt the shaft was carried downward by hand tools somewhat in advance of the drifts, and as it progressed the line of inclination of the floor and roof of the drifts was laid out on its sides, and the segmental light openings pierced ; through these it was easy to remove the material from the drifts, and to transfer the angle of the top and bottom of the drift from the lines established on the walls of the shaft. The position of the back wall of the drift could easily be accurately located parallel with the wall of the shaft by measuring through these light openings.

The tools used by the Egyptians for quarrying and stone-cutting were sometimes made of bronze and sometimes of iron. Herodotus states positively that iron tools were used in the work on the Great Pyramid, which is probably the oldest structure erected by man now remaining. In his explorations of this pyramid Colonel Howard Vyse found a thin plate of iron embedded in the mortar between two of the courses of stones, where it had undoubtedly been placed more than five thousand years ago. Among the ruins of Naucratis (600 B. C.) there were found a few years since, in what appeared to be the remains of a manufactory of iron implements, twenty-eight iron or steel chisels evidently designed for cutting stone or iron.

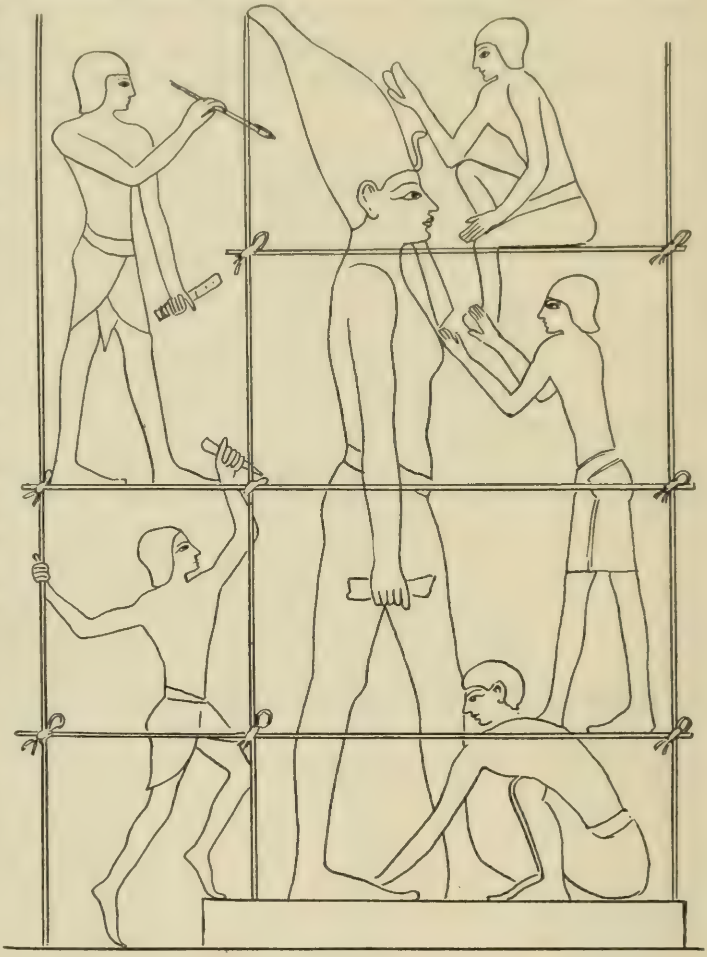


FIG. 15.

It is a singular fact that none of the very few bronze tools that have been discovered are now sufficiently hard to be used for dressing stone, and it is not at all probable that such tools were used except for the softest materials. The reason why so few steel and iron tools have been discovered is doubtless to be found in the perishable character of these metals, for unless tools made of them were placed in a position free from air and moisture, the sharp and hungry tooth of oxygen would rapidly gnaw them to destruction.

In addition to tools of iron, steel, and bronze, the early Egyptian workers in stone without doubt employed tools similar to the “diamond drills,” and “diamond saws” of our day. The plate (Figure 9) taken from W. M. Flinders Petrie's work descriptive of “The Pyramids and Temples of Gizeh” exhibits some of the evidence he has discovered of the use of diamond drills and saws. It is not certain that the diamond was the jewel used to arm these implements, but it is certain that the Egyptians were acquainted with a cutting jewel far harder than quartz, and that some such jewel was used as a sharp-pointed grooving tool is placed beyond doubt by the fragments of diorite bowls with inscriptions of the fourth dynasty which were found by Mr. Petrie at Gizeh. “These inscriptions were not scraped or ground out, but were plowed through the diorite. As the lines are only $\frac{1}{150}$ inch wide (the figures are about $\frac{2}{10}$ inch long) it is evident that the cutting-point must have been much harder than quartz, and tough enough not to splinter when so fine an edge was being employed,—probably only $\frac{1}{200}$ inch wide. Parallel lines are grooved only $\frac{1}{30}$ inch apart from center to center.”

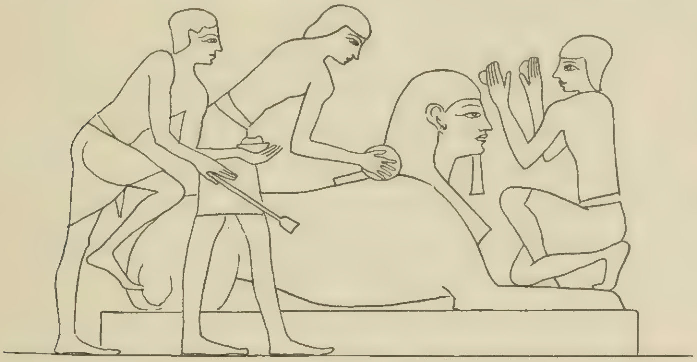


FIG. 16.

That the blades of the saws were of bronze is proved by “the green staining on the sides of the saw-cuts, and on grains of sand left in the saw-cut.” The forms of the tools in which jewel cutting-points were employed “were straight saws, circular saws, tubular drills, and turning-tools for lathes.” “The straight saws varied from $\frac{3}{100}$ to $\frac{2}{10}$ inch thick.” “The largest were eight feet or more in length.” The examples of saw cuts shown in Figure 9 are as follows: No. 1, from the end of the Great Pyramid coffer of granite; No. 2, a piece of syenite picked up at Memphis, showing cuts on four faces, and the thickness of the saw by a cut across the top; No. 3, a piece of basalt, showing a saw cut run askew and abandoned; No. 4, another piece of basalt, showing regular and well-defined lines; No. 5, a slice of basalt sawn on both sides and nearly sawn in two; No 6, a slice of diorite bearing equidistant and regular grooves ot circular arcs, parallel to one another; the only possible explanation of this piece is, that it was produced by a circular saw. The tubular drill-holes vary from $\frac{1}{4}$ inch to 5 inches in diameter, and from $\frac{1}{30}$ to $\frac{1}{5}$ inch thick. The smallest hole yet found in granite is 2 inches in diameter, all the lesser holes being in limestone or alabaster, which were probably worked merely with tubes and sand.*

The examples of tube-drilling in Figure 9 are as follows: No. 7, core in granite found at Gizeh; No. 8, section of cored drill-hole, in which the core, being of tough hornblende, could not be entirely broken out and remains to a length of $\frac{8}{10}$ inch; No. 9, alabaster mortar, broken in course of manufacture, showing core in place, found at Kom Ahmary by Professor Sayce; No. 10, the smallest core yet known, in alabaster, found at Memphis; No. 11, marble eye for inlaying, with two tube drill-holes one within another, showing the thickness of the small drills; No. 12, part of the side of a drill-hole in diorite, from Gizeh, remarkable for the depth and regularity of the grooves; No. 13, piece of limestone from Gizeh, showing how close the holes were placed for removing material by drilling; the cusp shows that the groove of one hole just overlapped that of the other. An example of tube-drilling on a large scale is found in the Great Pyramid coffer, which was hollowed out by cutting rows of tube drill-holes just meeting, and then breaking out the cores and intermediate pieces. Traces of this work may still be seen, where two drill-holes have been run too deeply into the sides. At El-Bersheh (latitude 27° 42′) there is a still larger example, where a platform of limestone rock has been dressed down, by cutting it away with tube-drills about 18 inches diameter; the cylindrical grooves intersecting prove that it was done merely to remove the rock.

The lathe appears to have been well known in the fourth dynasty (about 3600 B. C.). Diorite bowls and vases of the old kingdom are frequently met with, and show great technical skill. A piece found at Gizeh and shown in No. 14 (Figure 9) shows that the method employed was true turning; a section of this piece is shown by No. 15.

For dressing stone the "points," chisels," and "mallets" used were quite similar in shape to those employed at the present time. In Figures 10 and 11 (from tomb paintings at Thebes) stone-dressers are seen at their work. Figure 10 shows the method adopted for obtaining a surface practically flat. After working "chisel-drafts" around the

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*In the early part of this century an English patent was granted to James Murdock (the inventor of the slide-valve, and chief assistant to James Watt) for a method of manufacturing water-pipes of stone. The stone of which the pipes were made was bored by means of a thin hollow cylinder of soft iron to which an alternate rotary motion was given, its lower end being copiously supplied with sand and water. In the years 1810–14 the Manchester and Salford Water Company laid water pipes of limestone (bored by Murdock's method) in the streets of Manchester. The bore of these pipes varied from three to eighteen inches, and they were made in lengths of about two feet. The prices paid for the various sizes were as follows:

3 inch bore,	4*s.* 11*d.* per yard.	9 inch bore,	18*s.* 8*d.* per yard.
4 " "	7*s.* 8*d.* " "	12 " "	30*s.* 9*d.* " "
6 " "	11*s.* 6*d.* " "	15 " "	35*s.* " "
7 " "	13*s.* 9*d.* " "	18 " "	45*s.* " "
8 " "	16*s.*		

W. F. D.

sides of the area to be dressed, the workman applied two "parallel-blocks" to the surface of the "chisel-draft" and stretched a string across the stone from the top of one "parallel-block" to the other; and then, by applying another "parallel-block" to the surface of the stone in contact with one side of the string, it was easy to note the depth to be removed. This method was employed only on vertical surfaces to avoid the error arising from the "sag" of the string if used on a horizontal side of a stone. In case a less degree of accuracy was satisfactory the string was simply stretched by the hand as shown in Figure 11. In Figures 12 and 13 Egyptian sculptors are seen using the hammer and chisel.

"Sometimes saws were used instead of 'chisel-drafts' to lay out the work; grooves were cut about half an inch deep around a block and the hammer dresser trimmed it down to the plane of the grooves. Often, in the case of sawn blocks, the surfaces to be placed in contact were roughly hammer-dressed to leave sufficient space for the cement, while just around the edges of the surface they were left quite smooth. Hence the stones would be in contact and the joints quite microscopical on the outside, while there was a fair thickness of cement on the extremely roughened surfaces inside the joint. The average thickness of the visible joints of the casing stones of the Great Pyramid was $\frac{1}{50}$ inch in 6 feet in length. The leveling of the stones was very exact, $\frac{1}{50}$ inch variation in one hundred square feet area, and a like amount in 40-feet length of joint was the largest noted. Surface plates were used, smeared with red ocher paint, and when the stones were too large for the plates diagonal drafts or saw-cuts were run." "On the sides of the forty-three granite beams (averaging fifty tons weight each) which roof the King's Chamber, and the spaces above that [in the Great Pyramid] the workmen's lines may be seen marked in red about half an inch wide; there are usually (1) a line at some definite distance from the dressed face, from which the dressing was gaged; (2) a mid-line at half the length of the beam; (3) a line near each end showing where it should be placed upon the supporting walls; (4) a line one cubit from each end, by which the lines of support could be measured off in case they were defaced; (5) small lines in black about $\frac{1}{10}$ inch wide marked on the red in some parts, to give more definite points of reference." "In lining a rock tomb with fine stone, each course was not gaged to a uniform height before it was built in; but after laying it a red line at the level of the lowest stone was run round the course to mark where the dressing down was to be done."

In India a peculiar hammer and chisel seem to have been used, the hammer being quite different from the wooden mallet employed by the ancient Egyptians. Alexander Kennedy, Esq., states * that "the only tools which they [the Indian stone-dressers] employ are a small steel chisel and an iron mallet. The chisel is short, probably not longer than twice the breadth of the small hands which work it. The chisel tapers to a round point like that of a drawing pencil, and this I believe to be the only shape given to the points of their chisels. The mallet I have seen is of iron. It is somewhat longer than the chisel; its weight cannot exceed a few pounds. The head, set on at right angles to the handle, may be from two to three inches long. It has only one striking face. The striking face is formed into a deep hollow which is lined with lead. Having with these two instruments only brought the stone to a smooth surface, it next undergoes the dressing with water in the usual manner with masons. It now only remains to apply the black shining polish, which is done as follows: A block of granite of considerable size is rudely fashioned into the shape of the end of a large pestle, the lower face is hollowed out into a cavity, and this is filled with a mass composed of powdered corundum stone mixed with bees-wax. This block is moved by means of two sticks, or pieces of bamboo placed on each side of its neck, and bound together by cords twisted and tightened by sticks. The weight of the whole is as much as two workmen can easily manage. They seat themselves upon or close to the stone they are to polish, and, by moving the block backwards and forwards between them, the polish is given by the friction of the mass of wax and corundum." In Figures 14, 15, and 16 workmen are seen putting the final polish on the work of the sculptor by the use of hand rubbers and polishing blocks.

Relative to the means taken by the native workmen to insure the horizontality of the bottom of the socket in the plinth of the Seringapatam obelisk, Colonel Wilkes says: "I was satisfied with the means taken for insuring a true horizontal surface for the base of the shaft; but its stability entirely depended on equal accuracy in the surface of its receptacle; and, seeing no mode by which, with their rude instruments this object was to be attained, I so far departed from my first intention as to offer them a spirit-level and instructions for its use. They quickly understood and admired the contrivance, but were afraid of venturing on new methods; their own was (as they affirmed) more slow but equally certain, and they invited me to inspect it. The surface was rubbed clean and dry, and some water was dropped on it; the water ran! "*You see*" (said the engineer) "*the high* and the *low.*" He dried up the water and applied the chisel to the higher portion of the surface, and, by the patience and perseverance of several days, the surface was perfectly polished, and a drop of water remained stationary wherever it was placed.'' ''The whole obelisk received a very fair degree of polish from *corundum*. A piece of plank is overspread with the sort of cement used for setting sword-blades in their handles; whilst this substance is still liquid it is mixed and powdered over with pulverized *corundum* (reduced to a coarse or fine sand according to the purpose for which it is intended) and then left to dry in the sun. These planks, weighted over, are then used like the slabs of the stone polisher in England.''

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* Paper read before the Royal Society of Edinburgh, February 14, 1821.

Much more of interest might be said, but the boundaries of our limited space have already been passed, and I am admonished to forbear; and as I relinquish my pen I am reminded that with all their technical skill the ancient delvers never—so far as we are at present advised—attempted to quarry a magazine article out of history, and have it fill with precision the allotted space.

NOTE.—The principal works consulted in the preparation of this paper were:
Wilkinson's Manners and Customs of the Ancient Egyptians.
Perrot and Chipieh's History of Art in Ancient Egypt.
George Rawlinson's Five Great Monarchies.
Ewbanks's Hydraulics.
Transactions of the Royal Society of Edinburgh (1821.)
W. M. Flinders Petrie's Pyramids and Temples of Gizeh.
W. M. Flinders Petrie's Naucratis.

W. F. D.

ART IN THE FLOOR-PLAN OF A BUILDING.

By Thomas Hastings.

THERE seem to be two mistaken tendencies in our American methods of architectural education: on the one hand, to teach architects in a scientific or literary way; on the other hand, to teach with an absolute disregard for the proper and legitimate methods of work and study in our art, as if these methods were inartistic. Our methods of study should be as peculiar to us as those of the sculptor, painter, and musician are to them.

The one class of men with whom we have to contend includes those who would dispense with the triangle, compass, and T-square, and with such familiarity with the orders and with the principles of composition as will enable the student to use them with the utmost facility. They neglect these things, forsooth, to make room for what they call clever sketching. These men seem to have a peculiar disdain for the legitimate means of study, as though they were inartistic. The other class of men, the pretended *savants*, would learn their profession as though a good knowledge of the history and literature of their art, with a course of general lectures, were all-sufficient if followed by a few years of practical office experience. To the so-called *savants*, or the men who would teach architecture only in scientific or literary ways, it should be said that architecture is an art rather than a science, and that when the architect is most skilled in his art, then he has least need of recourse to science. Of course, an architect must be familiar with descriptive mathematics, for the purpose of calculating the intersection of vaults, roofs, and various problems in stereoptomy. Yet, if the floor-plan has been well studied from an artistic or esthetic point of view, there will rarely be left other difficult engineering and mathematical problems for the architect to solve. Here is the key to the entire problem.

I shall first endeavor to make clear the fact that there is such a thing as art in the floor-plan. There seem to be few architects in America who realize that the floor-plan is anything more than a mere matter of the convenient arrangement of the several parts of the building. A good floor-plan, as seen on paper and before examining into the questions of arrangement, has proportion form, scale, color, values, and character. The drawing of the plan will awaken as much enthusiasm in the educated architect as does the picture in the painter, or the statue in the sculptor. This plan should be thoroughly studied and practically finished before the architect has more than a vague idea of the design of the exterior of the building. The plan involves and determines the entire composition ; the silhouette or outline of the whole structure is really projected on the plane of this drawing,—*i. e.*, the thickest walls and the heaviest piers are the portions of the outline of the building which go the highest, for the silhouette is the necessary outcome of the artistic relations of these different wall- and pier-thicknesses to each other. We know that when a pier is five feet square in plan, whether it is the foundation of a tower or the foundation of one of the corners of a dome, it must go higher than the wall next to it, which is only two feet thick. The relations of the wall to the pier must look well on paper. If the proportions and the relations of the walls to each other are good, the silhouette will prove to be good when seen in perspective after the building is complete.

The floor plan determines the entire composition, and it does away with the perspective drawing as a help to architectural study and leaves it no place except to explain a building to a layman. It is amateur-like to use the perspective for any other purpose. When the plan is well studied, then it constructs well and builds well, and we need very little of the analytical mathematics to assist us in our construction.

Until modern times, how much mathematics (besides geometry and the descriptives) did architects know, as compared with what we are given to learn, and what did they know of the strength of materials? With them it was mostly a question of good judgment, with a proper and uncommon understanding of constructive principles, and of stereoptomy and the other descriptive mathematics Analytical mathematics is comparatively a modern science. While, for example, there existed graphical rules for the approximate determination of the thrusts from arches as early as the thirteenth century, yet it is practically only within the past fifty years that the correct principles of analysis have been fully developed, and there is still room for improvement in this direction. Until recently architects probably never calculated the strength of their materials, or the thrust of arches and vaults. With them it was a question of intelligence, and not of ingenuity. It was the qualitative, rather than the quantitative, principles of construction that they studied, and these always based upon experiment or experience. It was by knowing how to avoid difficult problems *with art* in the floor-plan that they escaped having difficult analytical problems to solve. We must always give precedence to practice and truth before laws and theories.

To illustrate this principle, there may be many arches indicated in a well-studied plan, but the thrust of each is received, either by an equivalent thrust in the opposite direction or by a solid masonry wall, in line with the direction of the force, to buttress the arch.

In a well-studied floor-plan there will always be artistic reasons for making a pier economical in size and strong enough to support the weight that it has to carry. By pure mathematics we can only approximately determine what should be the size of a pier. The strength of materials must be estimated. We select at random several specimens of the stone to be used in our building. We obtain crucial tests from a machine designed for this purpose, and so we are supposed to learn from these few specimens the average weight per cubic inch which the stone will support. This we call our coefficient of strength in the stone chosen for our building. Taking into the account the fact that the quarry where the stone is obtained may have a great fissure running through it, or may have other imperfections, the mathematician enters upon his calculations to learn how large a pier built of this stone should be to support the weight that is to be above it. After this, the architect practically admits the inexactitude of his premises by increasing two or more times the size of the pier and calls this the factor of safety or ignorance. I believe in such calculations for purposes of verification, but in general the piers will be *about* as safe to build upon when studied by an educated architect as when calculated by engineers.

It is really architecture and well-proportioned masonry *versus* engineering and the iron girders. Each has its use, but they are not interchangeable. Buildings have stood for centuries, and this is solely because their plans, as seen on paper, were so well studied, so thoroughly artistic and beautiful, that constructive difficulties were avoided.

Now that photographs and illustrated books are becoming so accessible to the student, adaptation is a greater temptation to us than ever before. We compile more than we compose, but if our floor-plan is first thoroughly studied in an artistic way, to meet the practical requirements of the problem in hand, then, when interpreting this plan and designing the façade, we can neither copy nor adapt what was conceived for one thing, making it serve the purpose of another.

We must not disparage analytical mathematics for purposes of verification. So long as a great many inartistic buildings are put up, such verification is needed for the protection of human life. From innumerable buildings time makes its selection, but at the sacrifice of human life in those which fall, because the inartistic buildings were not subjected to analytical verification. But this kind of verification, especially in complicated and exceptional cases, should always be entrusted to experts or specialists. Of course there are exceptional and most unfortunate conditions imposed upon us in these days, under which conditions the plan has but a very small part to play in the solution of the problem, such as fifteen-story office-buildings on 20-foot lots.

Here all would agree that expert mathematicians and engineers should be called into consultation, just as they are called in for questions of steam-heating, ventilation, or electrical work. But with these exceptions in the well-studied floor-plan, the constructive problems solve themselves, so that we do not have to resort either to calculation or to mere ingenuity. The plan determines every perpendicular line, so that it is, in fact, almost impossible to build a structure that is absolutely unsightly, on a well-studied, well-proportioned plan. The thicknesses of walls and piers should be proportionately related to the spans of the arches, or to the distances and floor-spaces. The thickness of a column should be proportioned to the intercolumnication or distance between columns, and the whole should be looked upon almost as you would look at a drawing in black and white, the black portions of the plan indicating the walls and piers, the largest going the highest in the elevation. Therefore, the more art we have the less science we need. When a floor-plan has been thoroughly studied, then in developing the exterior or interior no changes will be needed, even in details. We shall be saved from adaptation instead of composition. In the further development of the scheme we need only fill our minds and hearts, however large, with the spirit, the ideas, and the sentiments of our age, and study and interpret the plan, in order to reach the best results. Thus art in the plan is the first great need.

In the schools where architecture is taught, in the United States, the lecture-room plays too important a part. The architect or professor who teaches does not come enough into personal contact with the student to criticise his work, and the advanced students are not enough in contact with the beginners, as is universally customary in the ateliers or the studios of Europe.

To the men who disdain these true methods of study, because they think them inartistic, I would say that we do too much mere sketching and not enough serious studying. The architect should not despise the T-square and the triangle any more than the musician should despise the key-board of his piano. Sketching plays a very minor part in architecture; yet how many architects feel, if they can make a clever sketch, that they are skilled in their profession. An architect's drawings should be looked upon only as architectural—merely as means to an end—and yet they need be none the less artistic and fascinating to the architect.

The architect should design in plan and not in perspective. The day is coming when the public and all honest critics will demand of design in architecture something more than mere taste and refinement of details; when the monument must be something more than a conglomerate of well-molded garlands, wreaths, and ribbons, well-proportioned windows and columns, or the use of materials fine in texture and color,—and this can be only when the plan is looked upon as something more than merely a question of convenient arrangement, and the picturesque as something more than an eccentric accumulation of accidentals and good details.

I would not be misunderstood. I would not disparage the thorough study of the plan from a utilitarian point of view. This is in fact the principal channel through which our life and habits influence our composition and style. Before beginning to study the general composition of the floor-plan, it is first necessary to reduce the problem to its simplest form from a utilitarian point of view, taking into the account the number of the principal rooms or divisions, and the use that they are to be put to, their sizes, and the most reasonable forms that should be given to them. This is, as it were, the theorem or the program of the composition.

If the question of disposition is not thus thoroughly understood at first, it will arrest the freedom of the mind and the imagination.

Of equal importance is the question of the position or site of the building, and the principal points from which it will be seen. Certain distributions of the several parts of the building that would be well for a low and flat country would be inappropriate for a hill. The streets, promenades, or squares, or possibly water—river, lake, or sea—should of necessity have a great influence upon this distribution. The architect should know how to dispose his masses and should calculate the different effects with these conditions of environment taken into the account; that is to say, the principal room may demand a certain outlook, and perhaps some other rooms must be seen from a given point of view. The plan which does not satisfy all such given conditions is not only impracticable, but must in consequence thereof be absolutely inartistic, for a good building must have obvious adaptations both to its uses and to its environment. These things must of necessity influence the general character of the design.

In general, it may be said that there are three kinds of floor-plans: the *regular*, the *irregular*, and the *picturesque*. A monumental floor-plan is always regular, unless the peculiarities of the site make this impossible. The regularity consists in the plans having one principal axis. The irregular plan is an adaptation to the imperatives of an irregular site. It secures as much symmetry, in the arrangement of its parts and proportions, as the limitations of the site permit. The picturesque plan is not merely eccentric or lawless, but is an attempt to conform to the picturesque conditions of the environment,—at the same time preserving as much of balance and symmetry in the details as such adaptation will allow.

The general form may be as irregular or unbalanced as the letter L, and yet have perfect symmetry and circulation such as will give interesting vistas in every direction. The general principles of composition are the same as in the case of a regular plan.

Having considered the plans of buildings, we come now to speak briefly of the plans of the immediate surroundings, which the French call "*the plan generale.*" They have a very characteristic name for this portion of the composition, which is the "sauce of the architecture." It is this portion of the design which unites or marries the building with its natural surroundings or the landscape. Most of the same principles of composition obtain in the planning of this portion of the work, as in the planning of the building itself. The silhouette must make first of all an agreeable ensemble with the silhouette of the building. If the surroundings will allow it, the building should be so placed as to have the greater portion of the grounds on one side of it. This is generally very desirable, and especially when the site is small in proportion to the size of the building. The object is to give a large and open space on this one side, instead of a small frame or fringe all the way around it. This is not only true in the case of a public building, but it is just as true in the case of a dwelling. It would seem as though this were a mere question of common sense, and yet how little the principle is recognized; how dreary are the suburban homes of the poorer classes in this country. It is mainly because a man, when he builds, places his small square house in the center of a square lot, with a square walk around the house, and a fence that forms a square around the walk, and, as though this were not enough, even the streets all form squares outside his lot.

While the landscape or surroundings should govern the general composition of the building in the beginning, the building should in turn, when completed, influence and govern the arrangement and composition of that portion of the landscape work which comes in immediate contact with it. This landscape work is to surround and to support the building, serving both as frame and as pedestal. The accessories of the architecture, such as the terraces, balustrades, paths, fountains, open spaces and vistas which come nearest to the building, and other architectural features, are really a part of the building.

While the plan of the surroundings does not need to repeat the form of the building itself, it should everywhere recall its principal axes and lines, and it should accentuate its general silhouette, just as where there is a pavilion or important feature in the building there should be a circulation in the surroundings leading up to it.

Fountains, balustrades, statues, and rows of trees, when desired, should be clearly indicated in plan. All these things, with the plan of the building itself, should hold together in one great ensemble, while there may be interesting detail in the form of niches in the verdure for statues, or recesses for seats or vases, and small round or square breaks taken off the angles where two paths meet. All these forms should be studied in almost exactly the same way as if they were in the plan of the building itself. A statue should rarely be placed in the middle of a lawn, but either in a recess or in the center of a square at the intersection of an axis with the circulations. The size of the statue, as represented by its pedestal, has a proper relation to the other surroundings and to the plan of the building. A statue generally looks better in a public square with an architectural background or in a formal garden in a recess on either side of a main avenue, with thick foliage behind it, instead of standing against an open sky. Generally speaking, therefore, it is best to keep statues out of the large parks which are more apt to be naturalistic, and put them in the small parks.

Something should be said with reference to the general plan of cities ; that is, the laying out of streets, avenues, or parks.

The planning of a city is rather an evolution in history than the work of an architect, and so gives valuable testimony to the different phases of the life of the people. Many of the most interesting souvenirs of the past are seen not only in the buildings and monuments, but also in the general disposition of the streets and public squares. How much art, however, may be displayed in the influencing of this evolution can be seen by looking briefly at some of the cities of modern times. The greater portion of every city is the result of the accumulated works of generation after generation. This development is determined by local circumstances, by the political constitution, and by the commercial and domestic life of the inhabitants.

But happy is the city whose development in the cutting of new avenues and the building of new squares and parks has been governed by the laws of art. In a general way, the cities which have most impressed us are those that have at least one great artery running through the interesting confusion and natural complication of its streets. For example, how much more lasting is our impression of Paris than of London. When we think of Paris, we first see that one main artery, with which we associate the great composition spread out before us when standing on the Place de la Concorde. On one side are the garden of the Tuilleries and the court of the Palace of the Louvre. In front of us is the magnificent avenue of the Champs Elysée, which terminates with one of the greatest triumphal arches ever built. To the south is the river Seine, and the beautiful bridge leading to the monumental portico of the palace of the Corps Legislatif. To the north, those two most splended buildings of simple and vigorous proportions, the Garde

Meuble, and between these the vista of that wide avenue leading to the façade of the Madeleine. In the center of the Place de la Concorde is an Egyptian obelisk; in the axis of the main circulation there is a large fountain, on either side and in axis with small circulations from the corners of the square; in different parts of the composition are colossal statues and a multitude of candelabra. All these things enter into the composition of what I would call the main artery of the heart of the city—one of the greatest plans that the world has ever seen. All this is in striking and interesting contrast with the rest of the city, which is so complicated that it seems utterly devoid of any plan and to be the result of mere accident. And yet all this confusing complication is the outcome of most serious consideration in the history of the city.

What impressions to compare with this have we of London, where almost all seems to be confusion, and what is our impression of New York as to its general scheme, where there is no interest either of contrast or of confusion? Rather the greater part of the city is laid out in monotonous squares like a checker-board, without any street or avenue leading up to any monument or other object of interest, and with the circulation in only two directions. It does seem that every modern city might have one great artery or central avenue, and as though it might be possible to avoid prolonging streets to an indefinite length without leading up to anything.

The New York municipal government has now in hand a most interesting opportunity to display artistic skill, and to illustrate some of these principles, by the selection of a site for the new city hall. Instead of crowding a small park or open space with a large building which would be entirely out of scale with its approach or surroundings, they should select a site in an inexpensive neighborhood, which should be near enough to Broadway to allow of the widening of a cross-street to lead up to the center of the building, as was done in the case of the Rue Sufflot in Paris, which leads up to the Pantheon, thus making the widened cross-street a short avenue of approach to the central motive of the building. This building would soon change and determine the character of its surroundings, and so increase the value of adjoining property.

Thus it may be seen that the same principles which apply to the most unimportant plan apply also to the monumental building, and to the general plan of its surroundings, as well as to the cutting of streets and the laying out of a city.

COMMERCIAL RELATIONS BETWEEN CUBA AND THE UNITED STATES.

By E. Sherman Gould, M. Am. Soc. C. E.

IN treating of the commercial relations of Cuba with the United States, we are confronted at the very outset by a serious difficulty in the shape of the scarcity of trustworthy statistics. The mathematics of the question is wanting. In order that this statement may not rest solely upon my individual assertion, I quote from the report for the year 1892 of the British consul-general at Havana, to his government, upon the trade of the island: "The difficulty of obtaining the necessary data upon which to frame anything like a comprehensive and accurate commercial report for this island is almost insuperable. I have met with similar difficulty in other Spanish countries, but never quite to the extent that I have encountered in Havana. No official statistics are published." In spite of this obstacle, much light may be thrown upon the subject by treating it in a general way, qualitatively as it were, and not quantitatively. Such is the object of this paper.

The island of Cuba is about 720 miles long, with an average width of sixty miles, containing thus some 43,200 square miles.* Its population is generally assumed at 1,500,000, of which about one-seventh is concentrated in the city of Havana and its vicinity.

The table on the following page, showing the amount of merchandise exported from Cuba during the calendar year 1892, is taken from the above-quoted report of the British consul-general, who gives it as probably approximately correct.

This table shows that Cuba is a country of practically two products (sugar and tobacco) and of one market (the United States). Indeed, we may almost say that it is a country of *one* product, so greatly does sugar outweigh in value the tobacco production. The same report states that nine-tenths of the entire amount of sugar exported goes to the United States.

In order to show the immense importance of Cuba as a sugar-producing territory, I give further on a table prepared for two years, by Messrs. H. Clark & Co., of Liverpool, with an additional column—the third—from *L'Economiste Français*.

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* See an article entitled "Business Opportunities in Cuba," by Mr. Eduardo J. Chibas, in the November (1892) number of THE ENGINEERING MAGAZINE.

STATEMENT OF EXPORTS OF THE PRINCIPAL ARTICLES OF CUBAN PRODUCE IN 1892.

DESTINATION.	Sugars.		Refined Sugars.		Molasses.	Honey.	Wax.	Rum.	Cigars.	Tobacco.	Cigarettes.	Scrap.
	Bags.	Hogsh'ds.	Barrels.	Boxes.	Hogsh'ds.	Tcs.	Arrobas.	Pipes.	Thousands.	Lbs.	Packages.	Kilós.
United Kingdom.	......	......	......	......	......	......	......	221	42,594	285	......	......
Holland	......	......	......	......	......	50	......	36	20	573	......	......
Germany.	......	......	......	......	......	655	......	......	18,419	33,837	260,950	230
Belgium	......	......	......	......	......	50	......	......	810	547	......	......
France.........	1	......	......	2	12	1,146	1,492	1,734	7,816	2,149	2,391,026	18,577
Spain & Canaries.	328,521	......	1,785	6,523	1,081	104	8,967	17,103	11,856	30,578	3,399,142	21,234
United States ...	1,154,193	6,995	......	......	6,544	254	2,486	162	81,512	176,086	7,979,199	80,712
Canada	2,500	......	......	......	......	......	......	......	257	......	4	100
Mexico & Guatemala	......	......	......	......	......	......	40	13	89	......	5,078,306	32
P'to Rico & Hayti	......	......	......	......	......	......	60	......	915	50	17,553,658	364
South and Central America......	10	......	......	5	......	......	12	1,972	2,424	201	5,878,468	182,948
Total......	1,485,225	6,995	1,785	6,530	7,637	2,259	13,057	21,241	166,712	244,306	42,540,753	304,197

This second table shows that, between 1891 and 1894, Cuba furnished one-third of the entire cane-sugar production of the world. Taken in connection with preceding statements, it also shows the immense sugar-consuming power of the United States. Not, however, that the whole of the great quantity imported by the United States is consumed there; no doubt much of it is reëxported in different forms, a certain quantity finding its way back to Cuba in the shape of "sweet goods."

It may be said, therefore, that the entire commercial existence of the island is dependent upon sugar. On the other hand, the cultivation of the cane, the grinding of it, the treatment of the juice, and the necessary transportation require a vast amount of machinery, implements, rails, and locomotives and other rolling-stock. Since Cuba has no such manufactures, all this material must come from abroad, and naturally much should come from the United States.

RETURN OF THE WORLD'S PRODUCTION OF CANE-SUGAR.

Countries.	Quantity in Tons.		
	1891–92.	1892–93.	1893-94.
Cuba	920,000	900,000	1,000,000
Puerto Rico	60,000	65,000	70,000
Trinidad	50,000	55,000	55,000
Barbadoes	60,000	70,000	65,000
Jamaica	30,000	30,000	35,000
Lesser Antilles	90,000	90,000	30,000
Martinique	25,000	35,000	35,000
Guadaloupe	55,000	55,000	50,000
Demerara	100,000	120,000	110,000
Réunion	40,000	35,000	40,000
Mauritius	114,000	80,000	150,000
Java	435,000	430,000	500,000
Brazil	185,000	200,000	230,000
Philipines	245,000	250,000	230,000
United States	170,000	200,000	240,000
Peru	37,000	45,000	60,000
Egypt	55,000	65,000	80,000
Sandwich Islands	135,000	125,000	130,000
Total	2,806,000	2,850,000	3,110,000

The value of the sugar exported from Cuba to the United States has no doubt frequently reached, if not surpassed, the sum of $60,000,000 in a single year. At any rate, it will be surely safe to estimate the total yearly value of all exports from Cuba to this country at that figure. This large sum must be paid back to Cuba either in money or in the exchange of commodities. In regard to this alternative we must recall the fact that Cuba has no manufactures of any account except cigars; that all the implements and machinery used in sugar-making and all the textile fabrics used for clothing, and even many articles of food, such as breadstuffs, butter, salt meats, and "canned goods," must come from abroad. That is to say, $60,000,000 worth of exports are sent by a country without manufactures to the greatest manufacturing country in the world, and one in which the danger of "over-production" is supposed to be a standing menace. Under these circumstances the mere statement of the question, "How should these imports be paid for?" carries its answer with it.

In this connection the following table, compiled from the records of the United States treasury at Washington, and showing the total value of exports from the United States to Cuba for two different years, will be of great interest, especially as it gives an idea of the varied character of American products which already find a market in the latter country.

This table shows that the balance of trade is largely against us, assuming our imports from Cuba to reach $60,000,000. There is evidently room in the island for at least thirty millions more of

American goods. The table shows also that about one-half of the value of our exports in 1893 consisted of breadstuffs, provisions, etc., while wood and wood-work amounted to about one-eighth, and coal, iron, hardware, and machinery entered the list for about a quarter of the total amount.

VALUE OF EXPORTS FROM THE UNITED STATES TO CUBA IN 1889–93.

Description.	1889.	1893.
Agricultural implements	$ 74,135	$ 130,341
Animals	14,264	39,401
Books	46,617	39,075
Brass manufactures	32,420	44,150
Breadstuffs	1,336,147	3,511,617
Bricks	4,922	95,489
Builders' hardware	80,285	395,464
Carriages	67,282	316,045
Car-wheels	1,908	18,073
Chemicals	223,784	386,562
Clocks and watches	17,399	26,551
Coal	581,094	931,571
Copper manufactures	13,692	48,656
Cotton manufactures	126,180	148,178
Cutlery	10,347	21,094
Firearms	3,030	3,055
Flax, hemp, and jute	301,290	86,478
Fruit	30,971	126,954
Glass	55,178	117,870
India-rubber goods	27,804	42,879
Iron manufactures, not otherwise specified	241,122	1,343,551
Lamp goods	28,326	51,389
Leather manufactures	166,334	181,476
Lime and cement	16,500	71,570
Machinery	965,242	2,792,050
Marble and stone	14,243	77,003
Nails and spikes	58,112	127,583
Oils	430,203	548,092
Paper	198,461	159,895
Provisions	3,267,883	5,611,076
Railway bars	20,240	327,411
Railway-cars	127,533	271,571
Saws and tools	115,232	243,544
Scales and balances	35,406	62,561
Sewing-machines	42,571	95,630
Steam-engines	10,493	130,652
Sugar and candy	19,941	35,911
Tobacco, manufactured	59,658	61,494
Vegetables	380,802	978,261
Wire	118,214	321,120
Wood and manufactures of	1,110,946	2,881,095
All other	820,987	701,656
Total	$11,297,198	$23,604,094

It is the wish of the editor of this Magazine, as well as my own, that the present paper should be written without the introduction of any political feature, but it is impossible to avoid all mention of the reciprocity treaty, if anything like completeness is aimed at. In regard to this point it will be most satisfactory both to the writer and to his readers to refer the matter to an outside judgment. I will therefore quote from the British consular report, already referred to. After speaking of the difficulty of obtaining trustworthy statistics, the report says:

> It will be seen from the above article that the difficulty—especially to a new-comer—of forming anything like a clear and accurate view of the commercial movement of the district is next door to impossible. But, unfortunately, there is one feature of a very unsatisfactory nature, which stands out prominently and did not take long to discover, namely, that British trade with Cuba has almost become a thing of the past; and under the recent reciprocity treaty the United States of America practically supplies all the wants of the island and receives all its produce. . . .
>
> Machinery, which formerly was largely supplied by England, Germany, France, and Belgium, now nearly all comes from the United States; and the machinery required for the vast amount of sugar manufactured in Cuba is immense and of great value. . . . .
>
> The reciprocity treaty between Spain and the United States would appear to be mainly beneficial to the latter nation. Articles such as machinery, iron, steel, coal, etc., which formerly came principally from Europe, and continue to pay duty when imported from those countries, are admitted free of duty when coming from America, so that the former trade is fast disappearing, although some articles of English manufacture and of superior quality are still able to compete, notwithstanding the duty. The free admission of flour makes bread cheaper, but this is the only article which seems reduced in price. The free admission of Cuban sugar into the large markets of the United States is, of course, the great inducement for Spain to enter into an arrangement by which she sacrificed a considerable portion of her customs revenue. . . .
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> The effect of the recent reciprocity treaty between the United States and Spain in regard to her West Indian colonies has been to throw nearly the entire Cuban trade into the hands of the United States traders, with whom importers of goods from less favored nations cannot compete, having to pay, by the terms of such a treaty, higher import duties.

The Western of Cuba railway, now in English hands, and recently extended from Havana to Pinar del Rio, in the heart of the finest tobacco region of the island, has called largely upon the United States for its new work. Many hundred feet of iron bridging were furnished and erected by the Union Bridge Company of New York, the railway company being satisfied with the price, and their engineer, as well as the government inspectors, satisfied with the work. The cement used was also wholly or largely American, the American being adopted rather than the English, somewhat reluctantly by their engineer, on account of the greatly reduced cost. The stone used for bridge-seats was American granite, and highly praised to me by the engineer, who, being a Scotchman, was naturally a good judge of the material.

The fact merits attention, in estimating the value of the Cuban market, that the people are heavy buyers. There is very little saving practised. I do not think there is a single savings-bank on the island. A friend of mine, Captain Justiz, of the regular Spanish army, has recently organized a coöperative society among his fellow-officers with results which so far, I believe, are satisfactory, and a savings-bank in the same connection has been spoken of, but the organization of this society is the only step that I know of having been taken in the way of intelligent economical measures. As a rule, all money received is freely spent, particularly by the poorer and middle classes, who, of course, form the bulk of the population. Probably the pernicious system of government lotteries has something to do with the absence of saving, as the practice of purchasing tickets is as widespread among the poor as it is destructive and demoralizing. Probably, too, the character of the climate and the consequent ease of living prevent people from devoting much forethought to a future that they do not dread, for there is really very little of that pinching want ever felt in Cuba which recent hard times have brought to notice in our own country. Be the cause what it may, the fact remains that all the Cubans are prodigal in their expenditures, which goes far to account for the immense quantities of goods consumed and paid for by a comparatively small population.

Enough has been said, I think, to show that Cuba offers a most inviting field for American enterprise. Her prosperity and even her very existence may be said to depend upon her commercial relations with the United States; the two are bound together by the strong ties of mutual interest, and everything points to the fact that, commercially, Cuba should be ours, and this is the only kind of possession of the island, be it said in passing, that at present would suit either Spain, Cuba, or the United States. We want no other conquest of Cuba than a commercial one, and such peaceful conquest would be of common benefit to the three parties most concerned, and, I think, to all the world. I believe that if the trade, not only of Cuba, but also of all the South American countries, were first poured into the United States as a receiving reservoir, it would be naturally distributed, directly or indirectly, over the world to better advantage than if distant and various nations were carrying on desultory and independent business relations with them. The purchasing power that would be gathered into and concentrated in the United States by such trade would be largely expended in procuring those requirements of an ever-advancing refinement and civilization which Europe can at present, at least, furnish better than we can ourselves. We appreciate and want these things—none more so—and the wealth which a practical monopoly of the

South American trade would give us would make us Europe's best customer for those things of which she is the best producer. But this is a digression.

The Cuban market, like all others, is governed largely by fashion. Hitherto all supplies, except perhaps locomotives and steam-boilers, which have for a long time been chiefly furnished by the United States, have come for the greater part from Europe. I think that both in Spain and in South America French goods, as well as French manners and customs, have the preference. Just as there is a certain tendency in the United States to admire and imitate that which is derived from English sources, so everything French is apt to "go" in these countries. It naturally takes time to overcome such preoccupations, particularly as in many cases they are well founded. I have taken occasion elsewhere to call attention to the fact that American houses shipping goods to Cuba put themselves under a quite unnecessary disadvantage by careless packing. In the case of many fancy articles the mere appearance of the package goes a great way, and in the case of all goods careless packing entails great loss from breakage. This loss is a two-fold one for the American dealer. Not only does he have to make good the damage at his own cost, but he creates a prejudice against his goods and his ways of doing business. This brings up another important point. It is a great mistake to suppose that "anything is good enough for Cuba." On the contrary, the people there not only want the best, but they also know it when they see it, and, once deceived, they never have any further transactions with the deceiver. The market is perhaps a capricious one, but it is one that fully recognizes and appreciates fair dealing, and there is no better or more paying advertisement than to enter it "on the square."

The market being such as it is, and, moreover, being for many classes of goods a new one, the agents employed in it should be carefully selected. Here, again, Americans are at a disadvantage. Very few of the commercial travelers who are sent out from the United States speak Spanish, whereas nearly all those representing foreign concerns do. The Americans are therefore obliged to put themselves entirely into the hands of agents and interpreters, which is always an unsatisfactory way of doing business. In view of the growing relations between the United States and the South American countries, it would seem as if Spanish should occupy a preferential place, in our educational institutions, over the French or the German. Our business is to invade the Spanish-speaking territories, whereas we are ourselves invaded by the European nations, and this fact necessitates a more perfect equipment on the part of our business agents entering the foreign field.

As regards the classes of goods most needed in Cuba it would be impossible and wholly unnecessary to particularize more fully in this paper. We may broadly say that everything needed in this country is needed in Cuba, within the limits imposed by the difference of climate. They want or can be led to want everything we can furnish, that is good and cheap.

I may perhaps be here permitted another digression. We have heard a great deal in times past, and more particularly of late, of "over-production," and it is supposed to account for many of our business troubles. Now, over-production is a strictly relative condition, and its remedy is either to produce less or to dispose of more. Political economists tell us that true material progress lies in commonizing the good things of life, so that what to-day are the luxuries of the rich, shall become to-morrow the ordinary possessions of the middle classes, who will in their turn relegate their previous simple comforts to the poor, thus establishing an ever-ascending scale of prosperity, and raising, as it were, the standard of poverty. It is impossible, I think, to deny the truth of this proposition, which dictates a *leveling up*, instead of the socialistic plan of *leveling down*. In this view it is plainly to be seen that we are not, and cannot be, in any danger from *over-production*. What we and all the world are suffering from is *under-distribution*. The remedy, as far as the United States are concerned, is not to limit production, but rather to increase it even to its utmost possibilities and then launch out in quest of new markets. It is this policy which has given England her vast commercial supremacy in the past. She has never attempted to restrict the production of her manufactures, but her efforts have always been to open up new markets, until she has forced her way to the remotest regions of the earth. It is said that the sun never sets on the British flag; it certainly never sets on British manufactures.

In carrying out such a policy for the United States it is evident that the Spanish American countries offer themselves to us as our natural field for enterprise. As already pointed out, our labors in this field would be of mutual advantage to them and to us, and in more ways than one: while receiving from us our labor-saving machinery and wonderful mechanical appliances of all kinds, they would also imbibe a portion of the spirit which led to their invention and use. We, on our part, would not only receive from them the rich products of their fertile soil, but might also catch, by contact with men of another race, something of that natural grace and refinement in which our national character is said to be deficient.

It may be reasonably expected that the recent completion of the new Havana water-works by American contractors will form another link in the commercial relations between Cuba and the United States. These works have been already described and illustrated in this Magazine in the article by Mr. Chibas, already referred to, but a few details may not be out of place here. The contractors were Messrs. Runkle, Smith & Co., of New York, the present writer being their consulting and executive engineer from the commencement to the end of the work. It was begun in 1890, and the water was turned on in January, 1893. The final estimate considerably overran $2,000,000. The history of these works is somewhat curious. They were originally projected by an eminent Cuban engineer, the late General Albear, some thirty years ago, and a good deal of work was then done, including the collecting-basin for the springs, and the tunnel under the river Almendares,—both fine pieces of engineering. Many causes, however,—among them ten years of revolution,—combined to interrupt the work, and the failing health and lamented death of the distinguished author of the project deprived it of its leading spirit. The eminently successful completion of this work under American auspices undoubtedly marks a favorable era in the relations between the two countries, and I believe it may be truly said that it has increased the respect and esteem for the American name among the best elements of Havana business and official circles.

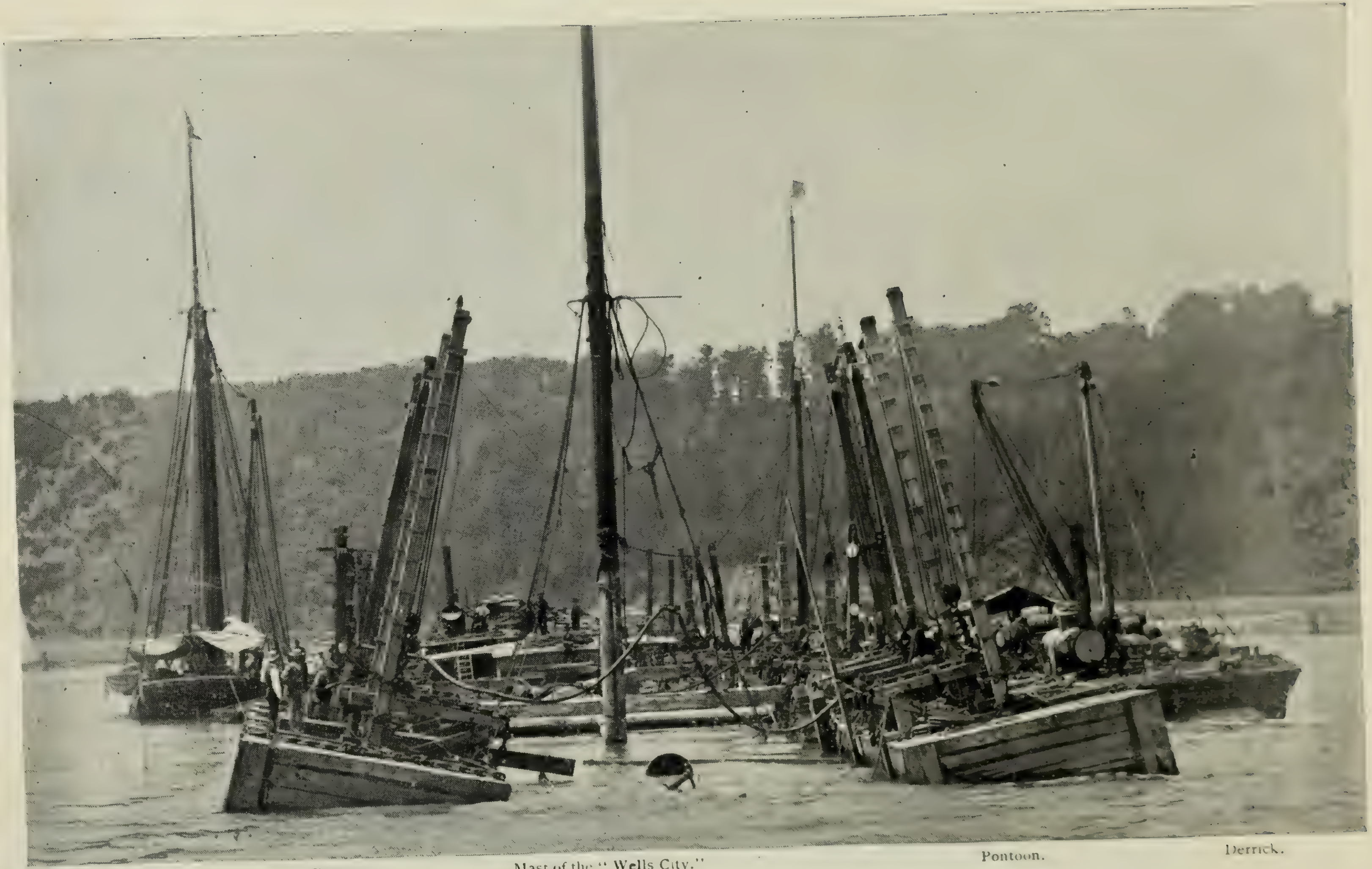
SAVING A WRECKED VESSEL.

By Gustav Kobbé.

IN ancient times, so far as we know, when a vessel went to the bottom, she stayed there. We have made advances since then, though not to so great an extent as might have been expected. If a vessel sinks inside a harbor or sound where there is comparatively smooth water we can raise her. But if one goes down at sea—outside of Sandy Hook, for example—we are still as helpless as the ancients. The "tools" for "outside work," as the wreckers say, do not exist. The surge would simply rip pontoons and chains to pieces. It is the unceasing motion of the sea, and not the depth, that makes it impossible to raise a vessel that has gone to the bottom of the ocean. Depth, to the limit at which a diver can work with certainty, say forty fathoms, is not a factor in smooth water. Inside work is successfully done on a large scale. But the ship which the open sea has drawn down into its depths can never be reclaimed. Otherwise, the greenish light which penetrates the surge off the Long Island coast would not disclose the helpless form of the *Oregon*, and other vessels which still lie where they went down would again be breasting the waves.

The man who has devised some apparatus for "outside" work is a familiar visitor in the offices of wrecking companies, who are asked to pass upon perhaps a dozen appliances of this kind every year. Some require novel fittings aboard ship to which the apparatus can be attached when anchored over the sunken craft, so that every vessel would be built with the idea that one day she was to sink,—a proposition to which probably neither builder, owner, nor skipper would care to subscribe.

While the raising of a sunken ship requires operations on a somewhat larger scale than getting a stranded vessel off a beach or reef, the latter calls for a vast amount of ingenuity. The number of difficulties to be overcome and sudden emergencies to be met would surprise one not conversant with the subject. Moreover, a stranded vessel must usually be got off in a storm but little less severe than that through which it came to grief, so that a wrecker must have the courage to face possible death by the very elements which wrecked the ship. The wrecker who, when the waves begin to pound threateningly against the stranded vessel, jumps over the lee rail and runs ashore, is as cowardly as the soldier who throws down his musket and



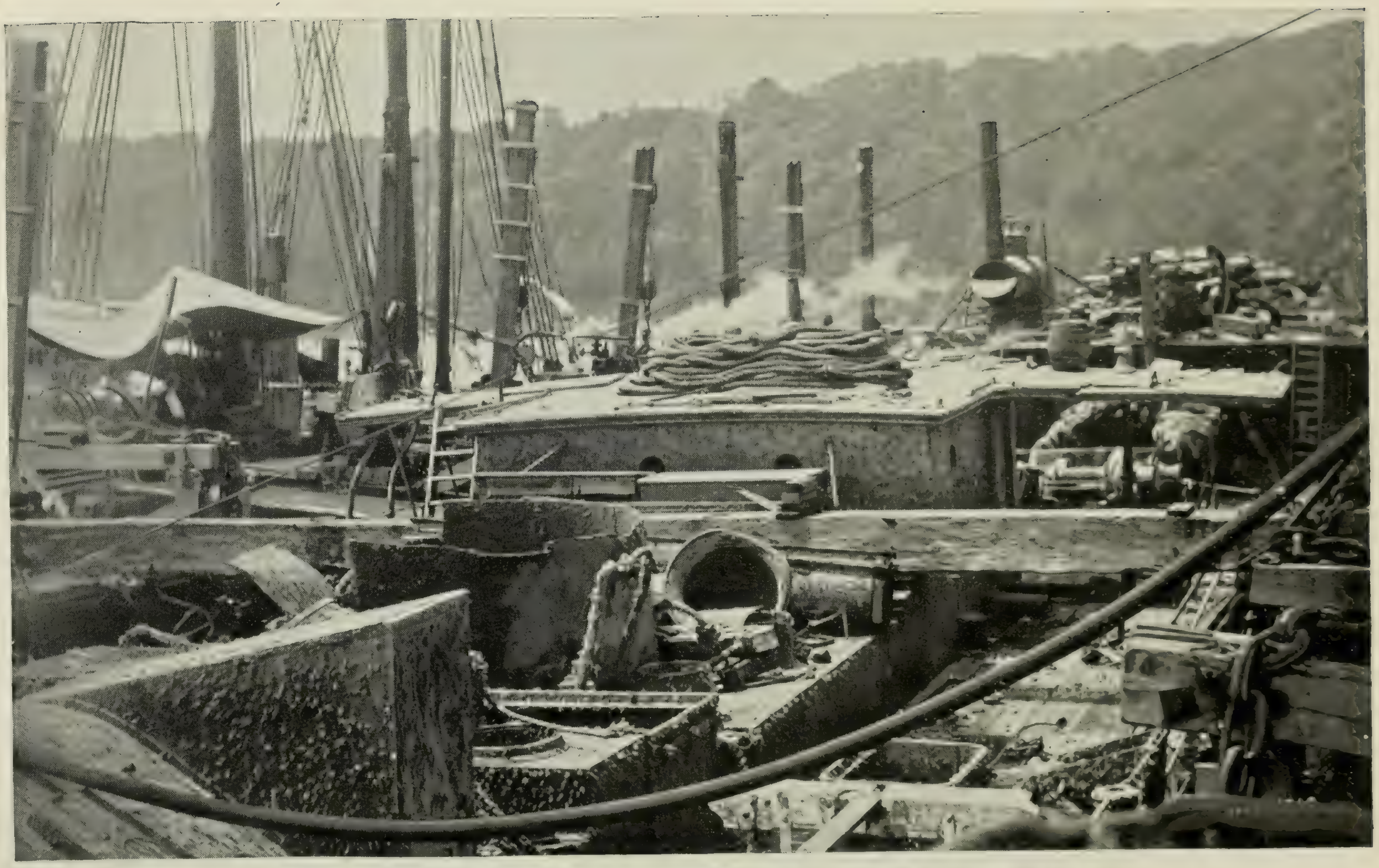
PONTOONS IN PLACE FOR RAISING THE "WELLS CITY," IN NORTH RIVER.

makes a dash for the rear. It is indeed an interesting feature of these operations that the sea—the power that throws a vessel helpless upon the beach—is by the wreckers coaxed or worried into aiding them in getting her off. Certainly there is poetic justice in this.

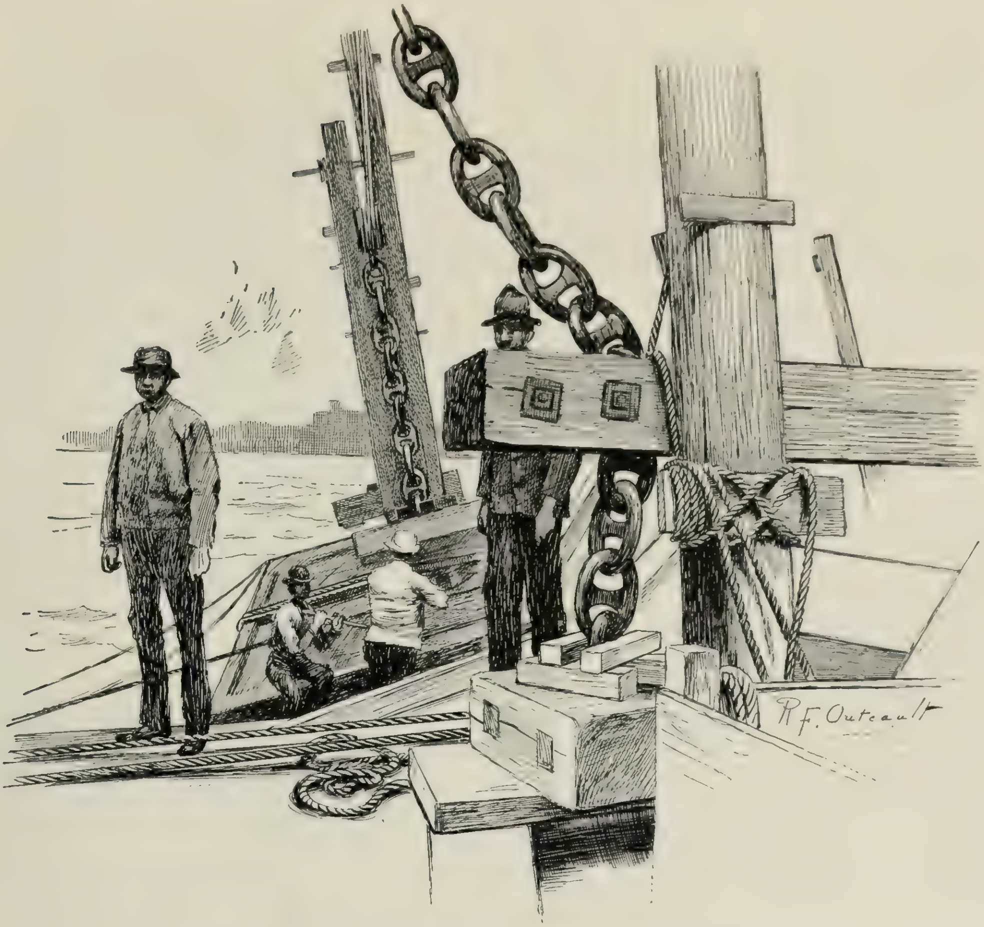
When a vessel goes on "light" she is of course cast up much farther on the beach than if she had been heavily laden, and the difficulty of getting her off is correspondingly greater. Launching a ship off the ways and getting her off a beach are two very different operations. The latter is like resuscitating the drowned. You may work and work and work—and, in the end, fail. But you have made a noble effort to bring, in the one case a human being, in the other a ship (which to me is almost human), back to life. There is an instance of wreckers having worked eighteen months over a stranded vessel. But they had the satisfaction of seeing her once more unfurl her white pinions to the breeze and, arching her bow over each oncoming wave, glide, like her old self, a thing of exquisite beauty, through the sea.

One of the wrecking companies in New York has as its trade-mark the picture of a stranded steamer, showing also the wrecking cables at her quarters. This is the *Pottsville*, the salvage of which is considered one of the finest pieces of work in its line ever done. This vessel went ashore in a southeast gale about ten miles north of Barnegat. She was light and was therefore driven high up on the beach. The procedure in cases like this sounds very simple, but details requiring instant decision are constantly coming up, where a wrong decision might be fatal to the enterprise. Briefly, you attach cables, with anchors seaward to the vessel, and, as the sea strikes her, she "goes to the cables." After you have lightened her of cargo or ballast, you stay on her and meet the elements; that is, fight what put her there.

Four cables, all told, are utilized in working off a stranded vessel. They are of manila, are from fifteen to twenty inches thick and 200 fathoms long, and have anchors with immense flukes weighing from 6500 to 7000 pounds. Two of these great cables are attached to the vessel itself, one to each of her quarters. It is calculated that, when there is a strain on these 200 fathoms of cable, an elasticity of from six to ten fathoms is developed, and it is this elasticity which causes the vessel to go to the cables when she is struck by a sea. The cables are protected aboard the vessel by great chocks which are themselves lashed with rope and thus increase the amount of spring. The other two cables, called "backers," are designed to increase the hold of the first two, and are attached to these about two-thirds their length out. These "backers" often come into play when the vessel has been got off the beach, but has still to surmount the bar. If the first cables



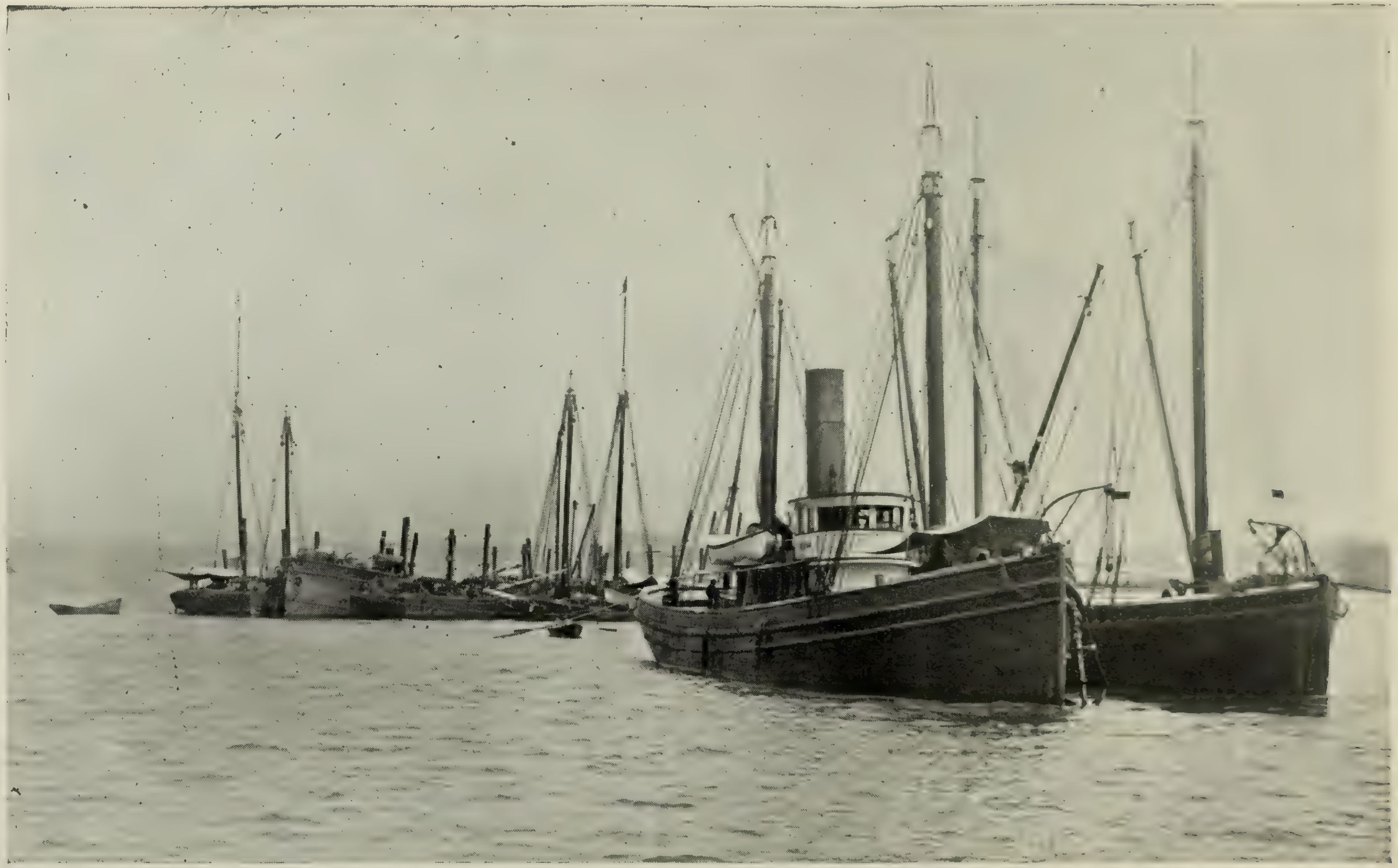
NEAR VIEW OF THE DECKS OF THE PONTOONS WHICH RAISED THE "WELLS CITY."



PONTOON CABLES USED IN RAISING A WRECK.

only carry her to the bar they are slipped and she is worried over the outer shoal by the "backers."

It required about five months to get off the *Pottsville.* She had been carried so far up on the beach that a storm severe enough to strike her and make her go to the cables would be severe enough to break her up. It was therefore impossible to save her as she lay. Means had to be devised to meet this difficulty at the outset. It may seem that the least likely method of rescuing a stranded vessel would be to ground her still more firmly. Yet that was what was done in the case of the *Pottsville,* and it was that which saved the vessel. They built a coffer-dam around her to a depth of 4½ feet below the line on which her keel lay, and running three feet wide around her. She was undermined in such a way that her keel remained resting on ridges or blocks of sand. Water was then pumped into the cavity. When it was full the ridges or blocks of sand which supported her keel were washed from under her with jets and she settled herself as lightly as an egg-shell 4½ feet further down into the sand. But sand, when the beach is



The " Wells City."

Wrecking Tug Ready to Tow Her.

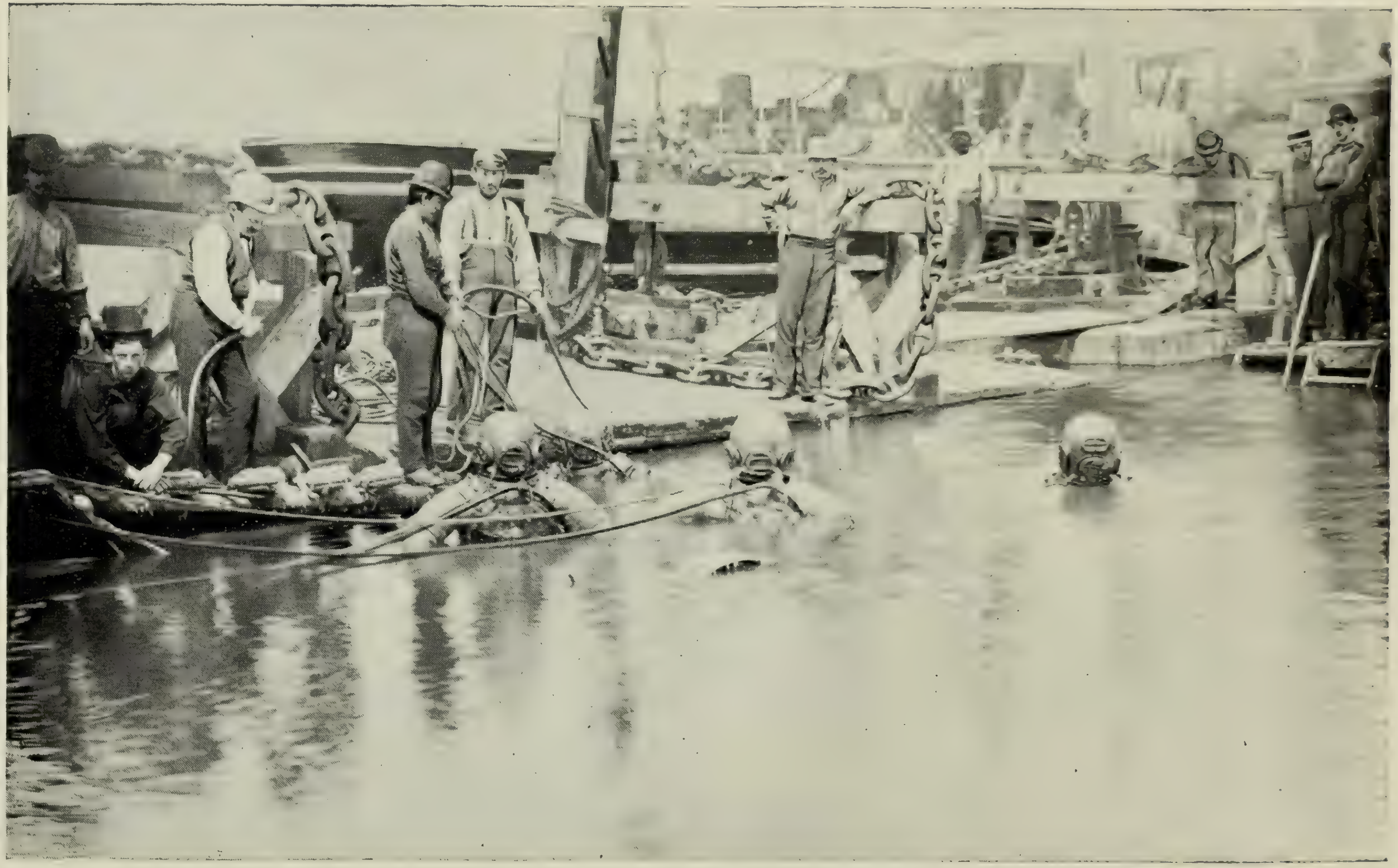
THE " WELLS CITY " AFTER BEING RAISED.

all awash during a storm, is little more than slush, and by means of this coffer-dam they had, as she sank 4½ feet deeper into the sand, brought her that much nearer her " bearings " or line of light draught; the effect, when the waves washed and struck her, being the same as if the wreckers had hauled her down the slope of the beach considerably nearer the surf-line. It took two months to build that coffer-dam, the planks being laid with hydraulic pressure and the nicest judgment being required to undermine her and yet leave sufficient support to prevent any shock or strain—but the coffer-dam saved her.

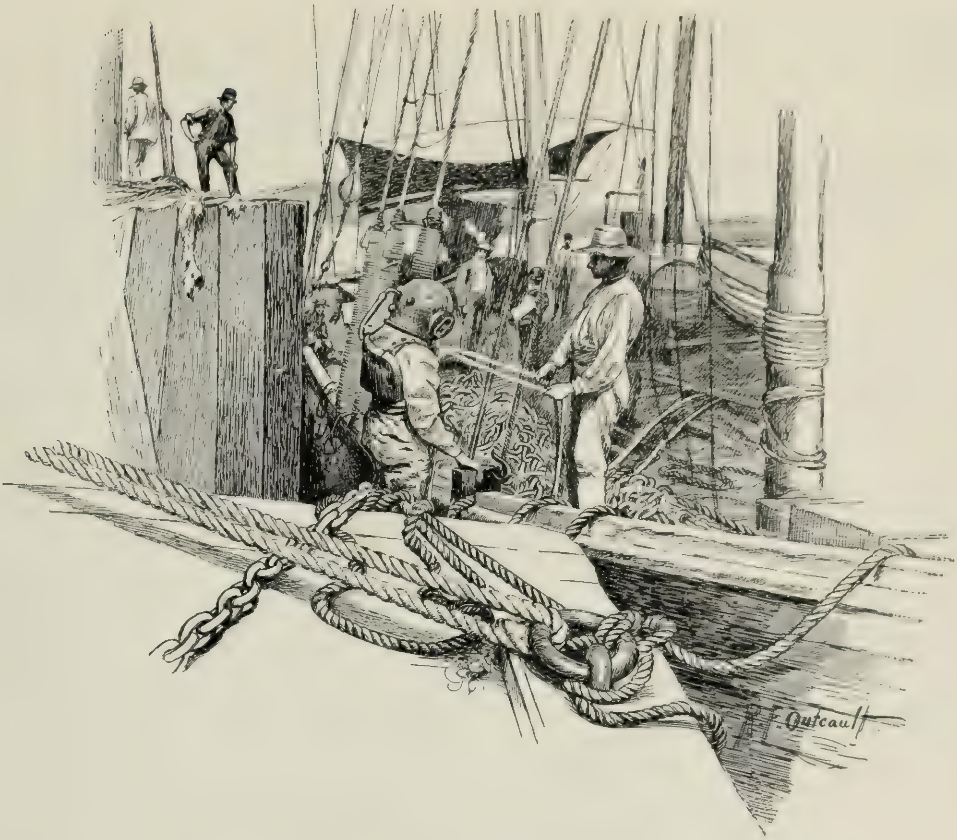
When the sea strikes a stranded vessel and she goes to the cables the wreckers haul in on the purchase and hold her; but it requires experience to know just the right moment to heave or slack, for the strain on the cables may become so great that they would snap like clothes-lines if they were not eased off at the command of an experienced superintendent. Sometimes the vessel will pound so hard that your teeth will rattle. Those are the times in wrecking when you need "sand" as well as experience. Here is wave after wave sheeting over the beach and breaking against the stranded ship, and instead of retreating before this angry sea you are deliberately getting nearer to it; struggling, not to escape from the jaws of death, but apparently doing your level best to get into them. And it is heave, heave, heave—toward the very fate which perhaps overtook the vessel's original crew.

As a matter of fact, wreckers have lost their lives in attempting to rescue stranded vessels. In the case of the *Circassian*, a full-rigged iron ship 280 feet long, which went ashore at Bridgehampton, Long Island, twenty-eight souls perished. This vessel had previously been stranded on Sable Island, and on Squan beach, New Jersey, a persistency in the wrong direction which would have had its humorous aspects had it not ended in a dire catastrophe. Among the wrecking crew who attempted to get her off the Bridgehampton bar were a number of Shinnecock Indians, and, for fear these might desert at the critical moment, the wrecking superintendent refused to comply with the suggestion of the keeper of the life-saving station that he run a cable ashore from the ship. The wreckers were warned that a storm of unusual severity was impending, but they knew that an unusually severe storm would be required to cause the large vessel to go to the cables. Instead of doing this, however, she broke in two in the furious seas that raged over her. No boat could be launched in such a surf to go to the aid of those who clung to the rigging, and no shot-line could reach them in the teeth of such a gale. The mizzenmast went by the board with thirty-two men clinging to it and of these only four reached shore.

No wrecking operations on stranded vessels have exceeded in ingenuity the rescue of the *Pottsville*. Of like importance in another



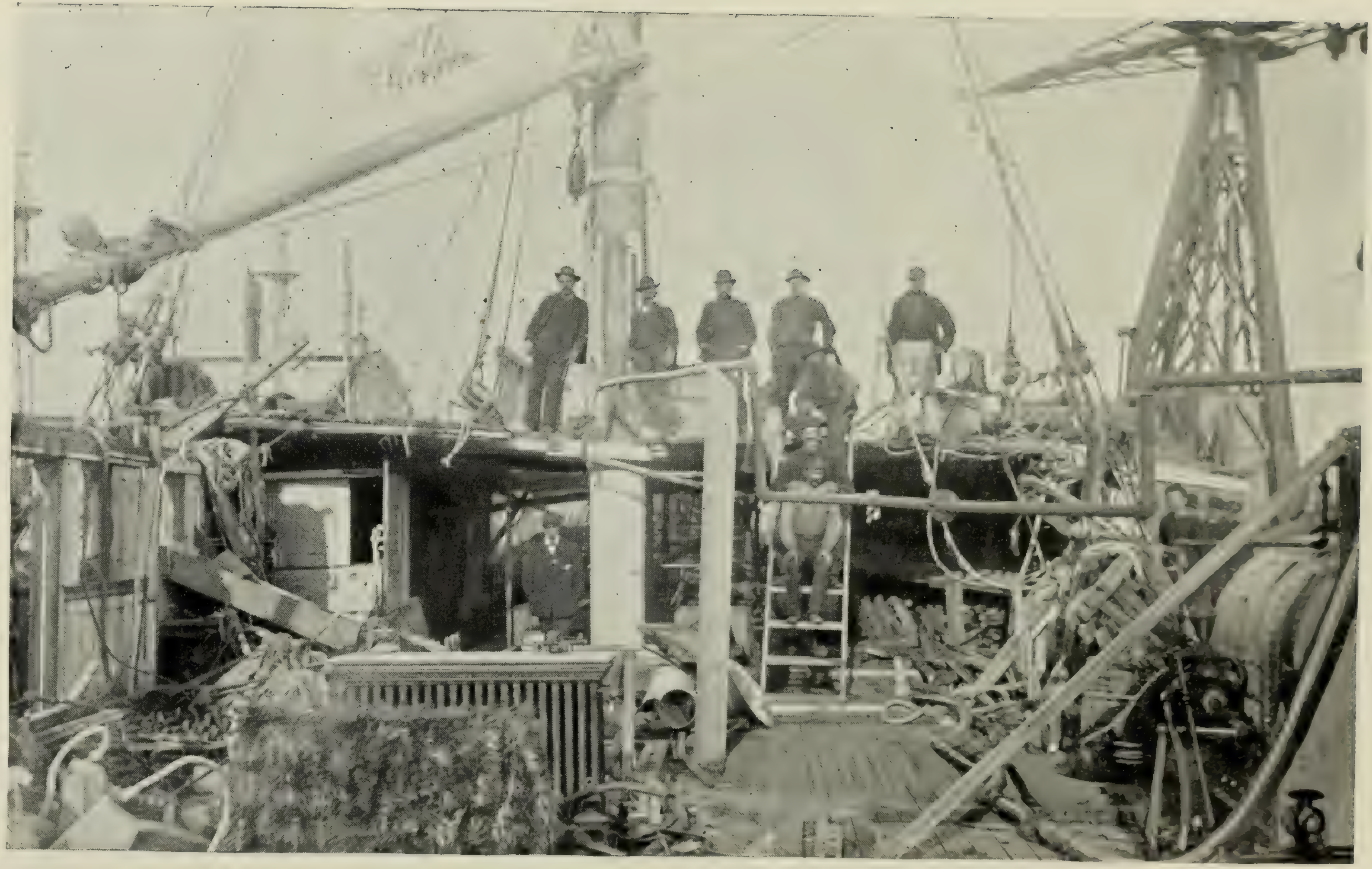
DIVERS READY TO DESCEND TO A SUNKEN SHIP.



A DIVER AND HIS APPARATUS.

line of wrecking, the raising of a sunken vessel, was the work on the *Wells City*, an English steamer of some 2000 tons which sank with a cargo of tin in February, 1887, off Christopher street, New York, and was for months an object of interest to the multitude of travelers by the Hoboken ferry. She had been anchored in the river some distance above the spot where she went down. One night the ice-floe caused her to drag her anchor and she was borne helplessly down upon the American steamer *Guyandotte*, which knocked a hole in her and sunk her. Nothing could be seen of her except part of her smokestack and masts. The ease or difficulty of raising sunken vessels is largely a matter of location; and the *Weils City* could hardly have been in a much worse place. She lay broadside to a strong tide so that the divers who worked in and about her were limited to the hour or two of slack water. Then, too, owing to sewage and refuse from shipping, the water is very dirty there, so that the divers were obliged to practically work in the dark.

The first evidence that an attempt was to be made to raise the vessel was the appearance of a powerful tug with a number of schooners with sailless masts but with decks covered with pumps, engines, coils of



DECK OF THE U. S. S. " TALLAPOOSA " AFTER BEING RAISED.

cable, and chains and diving apparatus. The schooners were anchored on either side of the wreck, while the tug lay to nearby. The first step in the operations was for the divers to take out the cargo of tin blocks. This, owing to the darkness of the water, required that the grips be adjusted to the blocks by the sense of touch, the divers remaining ever on the alert for the signal that would recall them before the tide began to rush in or out with such force that there was danger of the life-line or hose snapping—which latter means death. One night a canal-boat crashed into the smokestack and one of the masts, carried them away, and sunk over the *Wells City's* stern. The clearing away of the wrecked canal-boat and diving for the smokestack caused several weeks' delay and there were other vexing outside accidents due to the awkward location of the wreck.

The cargo having been removed, the six pontoons through which the raising power was to be finally applied were towed into place and distributed in pairs, three on a side, on either side of the wreck. The idea was to pass chains under the vessel's keel and up through the pontoons fastening the chain-ends to the pontoons; sink these by pumping in water to about a level with the river; then pump them out so that their buoyancy, applied at the chains, would raise the vessel a certain number of feet. She would then be towed into shallower water until she grounded and the operation would be repeated until enough of her was out of water to enable the wreckers to "plug her up" and pump her out when, of course, her own buoyancy would float her.

Three sizes of pontoons are used by the company which raised the *Wells City*. The largest, which have a raising capacity of 800 tons to the pair, are 96 × 16 feet and 11 feet deep. The two smaller sizes have a raising capacity per pair of 500 and 400 tons. The wells through which the chains pass are /\ shaped, so that the chain can run at an angle from the bottom of the pontoon without serious chafing. The three pairs of pontoons used on the *Wells City* had a greater raising-capacity than the ship's tonnage. But the fact that there were about eight feet of water over her deck and that a great amount of sediment had, as in all such cases, gathered in her frame and even under her ceiling, made this apparent excess of power necessary. Immense chains of three-inch thickness were used on these pontoons, but of course such thick chains cannot be passed under a vessel's keel without preliminaries. A sweep chain or "messenger" must first be worked in under. This is a small chain which literally saws in through the mud and stone at the bottom of the river to the point under the keel where the main chain is to be passed from pontoon to pontoon. Several chains of increasing thickness are then sent under, each acting as messenger for the next, until the three-inch chain is drawn through under the vessel to the pontoon on the opposite side. Chain after chain is thus adjusted until a sufficient number are in place. Sometimes the progress of the "messenger" is checked by a conglomeration of stone at the bottom. Then pumps are lowered and the obstruction pumped up. The company which raised the *Wells City* has in its cabinet of curiosities a stone nearly a foot long and proportionately thick. This stone was pumped up with a mass of other stuff, including a heavy lock which did not belong to the vessel at which the wreckers were at work.

The chains which are drawn by "messengers" under the vessel's keel pass up through the pontoon-wells to the pontoon-decks where there are toggles for fastening and adjusting them. The chains are examined link by link before they go into the water and there is an immense amount of heavy hammering and other smithy work done on the decks of the wrecking-schooners. When the chains are all in place the pontoons are pumped full. As they sink the slack of the chains is hauled in and made fast, so that the moment the pumping-out begins the lifting-power of the pontoons is applied, and, as they rise, they raise the vessel whose keel rests upon the chains in proportion as their buoyancy exceeds her weight.

The first attempt to raise the *Wells City* failed. For, as the vessel was lifted off the bottom, her keel cut through one of the chains as smoothly and cleanly as a knife cuts through an apple, and click, click, went the others, unable to bear the extra weight put upon them. This is one of the exigencies of wrecking. At the first attempt to raise the *Atlas*, which was sunk by a ferry-boat in the North river, a sudden surge grated one of the chains between the keel and some rocks on the bed of the river, and the keel cut through the chain like a cold chisel, the other chains bursting with the sudden excess of strain put upon them. It is, of course, an important point in the operations to equalize the strain on the chains. This is accomplished by thirty-ton hydraulic jacks and levers on the pontoon decks. The pontoons are connected by heavy timbers, and at the right moment a man rapidly makes the circuit of them and tests the strain. Experience enables him to tell at a touch if all is right. Thus a strain of tons is as delicately adjusted to the touch as is the key of a piano.

When the chains under the *Wells City* broke, the whole tedious operation, which can be told in so short a time but which occupies weeks or even months in the carrying-out, had to be repeated. At the next attempt, however, all went well and she was raised five feet. Then the wrecking-tug towed the six pontoons with the wreck, still submerged, suspended between them into shallower water. Raised again she was again towed nearer shore, and this was repeated until she could be coffer-dammed, plugged, and pumped out.

Some years ago the steamboat *Thomas Cornell* ran on a reef in the Hudson river near shore, with such force that her bow ran far up on the high bank, knocking away trees and scattering débris. It looked as if she were planted there forever, for she lay at a great angle, her stern nearly submerged, her bow high up on shore. To get her off was a delicate piece of work. The pontoons could be placed only along that portion of her which was in the water, yet to prevent her snapping she had to be lifted off at the exact angle at which she lay—and this was accomplished.

On the lakes, where there are few natural harbors and often deep water to the bank, so that there is no opportunity to ground a partially-raised vessel, they bring her right up where she sank. For this they use several sets of pontoons. Suppose, for instance, that four pontoons are on the spot. They partially raise her and hold her with one pair, and then go down and raise her further and hold her with the other, repeating this proceeding until they have her up.

For large vessels, like the *Wells City* and the *Atlas*, pontoons are the only practical lifting-power that can be successfully applied. Smaller craft can, however, be hoisted by derricks and in such instances these are often employed. A powerful derrick is now building for one of the wrecking companies and with this it is expected to accomplish greater results than have hitherto been attained by such means. Vessels which have simply stuck their noses into the mud or sand can readily be hauled off by tug-boats.

In accounts of foreign wrecking operations we often read of large vessels being raised. But these accounts are misleading. The tidal rise and fall are so great where the scene of these operations is laid that at low tide the vessel is comparatively high and dry and can be plugged up and pumped out—much the same as if she had been dry-docked.

In the cabinet of curiosities which I mentioned above I saw a sword which had gone to the bottom in three different vessels of the United States navy—in the *Cairo*, off Yazoo in 1862 ; in the *Conostoga*, in the Mississippi, in 1863; and in that terror of the seas, the *Tallapoosa*, in 1884.

TOWN-REFUSE DISPOSAL AND ELECTRIC-LIGHTING.

By Thomas Tomlinson, Assoc. M. Inst. C. E.

WHATEVER a town council may do or leave undone, it must make arrangements for sanitation and public lighting. When the town council, already burdened with the necessity and saddled with the cost of the collection and disposal of the town refuse, becomes also the provider of light for public and private purposes, it would seem that any suggestion as to the economy resulting from the combination of refuse destruction with electric-light production should be acceptable. The possibility of such a combination lies in the disposal of the refuse by fire in destructors and the utilization of the waste heat for steam-production, the steam being used in driving the engines employed in the electric-lighting.

Whether economy shall ultimately result from such a combination, or not, depends upon (1) the coal value of the heat so utilized ; (2) the total coal required for the production of the light (and power) required ; (3) the loss in distribution involved in the displacement of the electric station from the best available site (from an electrical point of view) to the destructor station, or interest on the extra cost, in distribution works, to keep the loss the same, or more generally some combination of the two ; (4) the difference in value of the sites and necessary buildings ; and (5) the coal value of the saving effected by condensation where the destructors are situated at the sewage outfall. In fact, whether a saving will be effected can be definitely stated in any particular case only when we have determined the total cost of a unit delivered at the consumer's terminals from the best available site from an electrical point of view and from the existing—or, if not existing, then the best available—site for a destructor station.

The necessity for such detailed examination would not exist if it could be shown in general that the coal value of the waste heat of the destructors was either very large or very small compared to the total coal required for electric-light production in any district. In the former case we should be forced to take the optimistic view that the combination of destructor station and electric station is always sound ; in the latter case we would be driven to the pessimistic conclusion that the combination is never sound, never advisable, unless of course under the extremely unlikely condition of the best available site, from an electrical point of view, coinciding with the destructor-station site—unlikely, because the best electrical site is that which is nearest the center of density of the lighting, while the destructor site is most likely to be on the outskirts of the district.

It becomes of importance, therefore,—and, fortunately, it is not impossible,—to arrive at some approximate general conclusions.

It will be advisable, at first, to confine our attention to the destruction of ash-bin refuse,—that is, of the house refuse collected from a district,—leaving out of sight for the present the possibility of dealing with excreta, water-carried or periodically removed from ash-pits, middens, or pans.

Ample statistics are available, both as to the quantity of ash-bin refuse collected yearly from towns of very different sizes and classes, and as to the value in steam-raising power of the waste heat; unfortunately, in both particulars, quantity and calorific value, the figures show a very wide range,—so wide in fact that, by selection of a suitable figure for quantities coupled with a suitable figure for calorific value, any proposition as to the value of the waste heat of destructors in connection with electric-lighting could be proved.

I have elsewhere* given, at too great length to repeat here, reasons for believing that, with a water-carriage system of sewage, the ash-bin refuse may, for general purposes, be taken at 4 cwt. per head of population per annum, and further, that the evaporative value of the waste heat of such refuse, burned in a destructor under sanitary conditions, is from 500 to 800 pounds of water evaporated per ton of refuse burned. For a population of 20,000, then, on these figures, the coal-value of the waste heat of the destructors would be 112 to 180 tons (assuming an average evaporation in a central station of eight pounds of water per pound of coal).

Now consider the probable demands of a population of 20,000 for light. On the usual assumption of one 8-candle-power lamp per head for 500 hours per annum, we would have to deliver 300,000 units at the consumer's terminals, requiring 10, 12, or 20 pounds of coal per unit, according as the system adopted were low-tension direct current, high-tension direct or alternating with substations, or high-tension alternating without substations; that is, we should consume 1340, 1600, or 2680 tons of coal per annum, according to the system adopted. The last system is practically obsolete, and the first rarely admissible over a wide area, so that, in general, we may take it that the question for decision is whether it is worth while to place the electric-light sta-

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*See *Electrical Review* (London), Vol. XXXIII, Nos. 819, 820, etc. Also, "Refuse Destructors and their Results up to the Present Time," by Charles Jones, with a chapter on "The power available from Destructors," by Thomas Tomlinson. Second edition. London: Biggs & Co.

tion on a site not the best for distribution, but with a bonus of 7 to 11 per cent. of the total coal required and possibly with the added economy of condensation (which would raise the percentage from 7 to 11 to 9 to 15), and taking into account the other factors in the cost of a unit delivered.

It should be noted that any increase in the efficiency of destructors and any increase in the amount of light obtainable from the combustion of a given quantity of coal (both of which are to be looked for in the near future) increases the value of the waste heat of destructors, by increasing the coal value of their waste heat as compared to the total coal consumption; on the contrary, any prospective demand for light above that here assumed will tend to diminish their value for the contrary reason.

So much for the immediate prospects of utilization of ash-bin refuse only. We pass now to the question of excrementitious refuse and the possibilities of its utilization; remembering always that the first point to be considered is the sanitary result of our operations, and after that the financial result—the possible return towards recouping the cost of collection and disposal. The excrementitious matter may be disposed of in four ways:

I. Water-carried and discharged into the nearest body of water, without precipitation or clarification.

II. Water-carried, the solids precipitated as "sludge" and the clear effluent alone discharged into the nearest body of water.

III. Periodically—at long intervals—removed from cesspits or middens into which ashes, cinders, and general household refuse are also deposited.

IV. Periodically—at short intervals—removed in pails.

In the first case the stuff is effectively dealt with—for the time being. Whether we have or have not transferred to a future generation, or our own grown older, a Herculean task of Augean-stable cleansing, depends upon the size of the waterway into which we discharge the refuse and the present and future size of our city.

In the second case we shall have to dispose of the sludge from the settling tanks—air-dried or pressed. As swept from the tanks the stuff consists of nine parts by weight of water and one part by weight of solids; after pressing it contains one part by weight of water and one part by weight of solids. Of this pressed sludge the amount obtained is from $1\frac{1}{3}$ to 2 cwts. per head population per annum. At first it was supposed to have high value as a manure, but now it is pretty generally recognized that it has practically no such value, and that it must be dealt with on the spot.

The first systematic attempt—in England, at any rate—to deal on the spot with both the ash-bin refuse and the sludge, and, so far as I know, up to now the most complete and most practical plan, is that adopted by Mr. C. Jones, M. Inst. C. E., at Ealing, near London. The plan adopted is interesting to us because it essentially consists in mixing the ash-bin refuse and the sludge—drained and-air dried however, and not pressed—in the proportions in which they occur (two of sludge to one of ash-bin refuse by weight) and burning them together in exactly the same type of destructor as is elsewhere used for ash-bin refuse alone; and further, because the calorific value of the waste heat per ton of the mixed stuff is represented by an evaporation of 700 pounds of water per ton of refuse burned, as against 500 to 800 pounds evaporated per ton of ash-bin refuse alone.

Now, as there are 4 cwts. of ash-bin refuse per head of population per annum and 1⅓ to 2 cwts. of pressed sludge per head per annum (and the higher figure will probably be the nearer the correct one for drained and air-dried sludge), we have an actual increase in total annual evaporation, or total annual power available, of from 16 to 30 per cent. by burning the two together, even if we adopt the highest figure of 800 pounds per ton burnt for ash-bin refuse alone.

By burning the ash-bin refuse and sludge together we therefore increase substantially our total output, and so increase the value of our destructor waste heat in connection with electric-lighting, and at the same time get rid of the sludge, which becomes a serious nuisance the moment its absence of manurial value is discovered in any district, and its disposal as manure by gift or sale becomes impossible.

This Ealing result will repay examination in another direction. Every ton of the mixed stuff contains ⅔ of a ton of ash-bin refuse and ⅓ of a ton of sludge; the evaporation due to the ⅔ ton of ash-bin refuse is $2 \times \frac{800}{3} = 533$ pounds of water; the total evaporation is 700 pounds of water; therefore the total actual evaporation due to the ⅓ ton of sludge is 167 pounds of water, so that the evaporation due to one ton of sludge is 500 pounds of water. Now, remembering that the sludge itself contains at least 50 per cent. of water, or 1120 pounds per ton, which must be evaporated before it can do any evaporative work outside the destructor, it is pretty evident that the solids and gases of the sludge must be of pretty high calorific value.

A very simple investigation will establish the main source of this to be the gases contained in the sludge. To establish this it is only necessary to distill a small quantity of freshly-pressed sludge-cake and to collect, and afterwards burn, the gas given off; this will be found to amount to about 3800 cubic feet per ton of pressed sludge. We may fairly enough take average results from a number of small samples as indicating the general results to be obtained on a large scale, owing to the homogeneity of the material; besides, there is at least one corroborative result on a fairly large scale—an experiment by Mr. Lomax of Nelson, Lancashire, which gave 3300 cubic feet of gas per ton.

The fact that sludge can be burned in an ordinary destructor, in combination with ash-bin refuse, is in itself of considerable importance, as it makes it possible to get rid of a very considerable quantity of material which, considering its composition, it certainly is not desirable to tip upon ground ever likely to be built upon, and for which, in the absence of manurial value, there appear to be only two alternatives—tipping or burning. The fact becomes more important when it is seen that the burning involves no loss, but on the contrary, a gain of steam-raising power in the waste heat of the destructor. There seems to be little doubt that, in any district where a system of house-to-house collection of ash-bin refuse is adopted, and where also the solid matters of water-borne sewage are precipitated before the discharge of the effluent, sanitary requirements will be best fulfilled by burning the two classes of refuse together, and that, under favorable circumstances which admit of the utilization of the total waste heat, the cost of disposal of the refuse may be considerably reduced,—probably below the cost of disposal in a less sanitary manner.

As indicating the possibilities of return towards reducing the cost of disposal, the statement of the result attained at Ealing is of value. The cost of destruction of the mixed stuff is stated to be 1*s* 6½*d* per ton (including interest on the cost of works) and the return in power and in the value of the clinker, for road-bottoming and path-making, is stated to amount to 1*s* 3*d*, leaving the net cost of disposal at 3½*d* per ton. This result is obtained with the old "Fryer," or low-combustion, type of destructor, having a fume cremator in the main flue; but at Leyton, another district of London, a plant is being erected to deal with the mixed stuff (the sludge being pressed, however) in one of the modern high-combustion destructors with forced draught, moving firebars and all the latest improvements.

It will be interesting, bye and bye, to compare the results of the two processes; but, with full knowledge of the danger of prophesying before the event, I shall look to the older combination to give the best results in value of the waste heat, and for these reasons: In the old style "Fryer" destructor the refuse is fed in from the back of the destructor and the flue leading to the main flue is always at the back of the destructor; therefore all gases given off at a low temperature will pass off, from fresh charges, unconsumed into the main flue. Indeed it was this, coupled with the fact that these gases stink abominably, which first brought destructors into disrepute and then led to the devising of the remedies—the addition of the fume cremator to the old type of destructor on the one hand, and the introduction of the modern or high combustion type of destructor on the other. The fume cremator is simply a furnace with reverberatory arch placed on the line of main flue. The gases pass through the furnace over a fire of cheap fuel to which they are deflected by fire-brick deflecting curtains turned in the reverberatory arch and are then raised to the temperature required for their combustion. Where the waste heat is utilized for raising steam the crematory is placed as near to the boilers as possible.

In the case of the high-combustion destructor, forced draught is used (usually a steam-jet) so as to raise the temperature of the furnace as high as possible and the flue leading to the main flue leads from the front of the furnace ; as the refuse is fed in from behind, the gases which are given off from the fresh charge must, before reaching the main flue, pass between the reverberatory arch of the furnace and the intensely hot fire below and there be consumed. In both cases the gases given off at a low temperature are consumed by being subsequently passed over a red or white hot fire.

It will have been found, in making the experiment in the distillation of sludge-gas, that the gas is given off at a low temperature and with extreme rapidity. Where sludge is burned in the low-combustion destructor the gases are consumed in the cremator, and where it is burned in the high-combustion destructor the gases are consumed in the furnace. Now in practice, when the waste heat of destructors is utilized for steam-raising, the boilers are necessarily placed at some distance from the destructors, the distance amounting to 100 feet or more in a big scheme. The great loss of heat due to the passage of hot gases through long lengths of flues is well known, especially in connection with fuel-economizers, which are always placed as close to the boilers as possible on this account, and it is reasonable to expect that in practice the return in power will be greater when the gases are burned close to the boilers in a cremator than when they are burned in the destructors at a distance.

An obvious further deduction may be made which may be of importance in future developments, namely, that a still better return would be obtained if the gases were ignited actually *in* the boiler-furnace. To do this it is only necessary that we should use the waste heat of the ash-bin refuse to distill the gases from the sludge, and, as the sludge is well suited for mechanical manipulation and gives off its gases readily, there is no practical difficulty in arranging for the necessary conditions for success of the sludge passing in a retort in a thin layer over a surface heated by the waste heat from the ash-bin refuse, nor is there much difficulty, if it were found advisable to do it, in passing steam or steam and air over such an incandescent layer and converting the carbon also into gas, to be subsequently burned actually in the boiler-furnaces.

In addition to the increased return to be thus attained, in all probability, there are two further points worthy of note. The power, in this form, would be capable of transportation and storage, easy, cheap, and with small loss ; the first—capability of transportation—would increase the value of the waste heat from destructors, in connection with electric-lighting, by freeing us from the necessity of placing the electric-light station in a position probably unsuitable and entailing loss in distribution ; the second—capability of storage—would still further increase the value of the waste, because it would render it available just when we wanted it and at a moment's notice.

The increase of value which would result from the location of the electric-light station not being confined to a possibly unsuitable site, may be inferred from the reasons already given as to the loss arising from its being so tied down ; the increase of value which would result from its being available at short notice, depends upon the fact that a considerable proportion of the fuel burned in an electric-light station is consumed merely in being ready for the coming on of the heavy load and in the large fires left on as the heavy load comes off ; this loss has been stated by Professor Kennedy, F. R. S., from observations on a large London electric-light system, at 10 per cent. of the total fuel consumed.

It seems then quite possible that, treated in the manner above indicated, the value of the return from ash-bin refuse and sludge of a given population may be increased from the 7 to 11 per cent. (as already deduced) to 15 to 20 per cent. of the total fuel consumed for the electric-lighting for the same population. If this result were obtained the cost of disposal of the refuse would be certainly covered, and perhaps also some part of the cost of collection and precipitation. The balance would have to be charged to the account of the public health, just as the whole is under a system of disposal to shoot. More than this cannot be expected—the city dust-yards and the sewage-works are no municipal El Dorados.

We pass now to the third manner of disposal of the excrementitious matter—periodical collection, at long intervals, from middens or cesspits. I am not aware of any town in which the collected stuff is disposed of otherwise than by carting it upon land as manure, which necessitates piling it up in huge heaps in the town-yard until the season for its application to the land comes round.

This brutal practice is, I believe, wholly unnecessary from an economical point of view—that is to say, the treatment of the midden refuse of any fairly affluent community burning coal may be made to pay for itself, or nearly so, by the return in power.

In an experiment recently conducted by me* on some ten tons of newly-collected midden stuff taken at random, I found that it was perfectly feasible to treat this stuff without offence and to have over a surplus of power (in the form of cinder and fine coal) which would pay for the cost of the treatment.

The process consisted essentially in driving off the moisture and gases from the stuff by heat in a closed retort, the steam and gas being drawn from the retort by a steam-jet ejector and forced through the furnace fire. The destruction of the offensive gases was so complete that the experiment was conducted with a 14-foot chimney within sixteen yards of a high-road without offence. The fuel for the furnaces of both the retort and boiler was supplied by part of the cinders and fine coal riddled from the treated stuff.

The result of the last experiment showed the following balance-sheet, the amount of refuse treated being 6 T. 17 cwt. 1 qr. = 549 qrs.:

	Quarters.	Per cent.		Quarters.	Per cent.
Fuel used.............	172	31	Pots, crockery, etc.......	16	3
Fuel over-cinders......	40	25	Clinker................	36	6
breeze.......	92		Ashes.................	22	9
Dust (carbonaceous)...	141	26	Water (by difference)...	31	

This experiment was made with an ordinary cast-iron retort which was very badly set and very inefficient. The retort was hand-fed but there is little difficulty in arranging for mechanical feeding, and the experimental result is so promising—a return of 25 per cent. of the total weight treated, as fuel over and above that required for the treatment and that with a single inefficient retort—that the engineer of a town with a midden system might do worse than consider the matter.

In this case also the return from the destructors is in such a form as admits of easy and cheap transportation and storage with these attendant advantages from our point of view; but it has not the advantage of being available at short notice as in the last case. In the fourth manner of disposal of the excrementitious matter—the pail system—no possible return in the form of power is available.

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*See *Electrical Review* (London), Vol. XXXIII, Nos. 824, 825.

THE PHENOMENA OF ALTERNATING MAGNETIC FIELDS.

By Elihu Thomson.

THE great advances made during the past seven or eight years, in the employment of alternating currents of electricity to supplement or even to supplant the continuous current in the transmission of power and in lighting, are well known. We are learning from day to day more and more of the wonderful capabilities of such currents as well as of their great flexibility. The facility with which we may transform electric pressures and currents in alternating-current work, so as to exchange a few amperes at thousands of volts pressure for thousands of amperes at a few volts pressure, or the reverse, is one of the great advantages possessed. The transformation, made as it is by a simple induction coil of wire and iron without moving parts, is also accomplished with such high efficiencies as 97 or 98 per cent. We may have alternating-current waves of any pitch or frequency, of any quality or shape of wave, of any amplitude or power. We may have two or more waves of the same pitch, but not in the same phase, working together in the same system or produced therein by suitable devices from a single wave. Thus arise multiphase or polyphase currents, the best-known relations of phases being two-phase and three-phase currents. The capability of such currents to produce rotary magnetic fields, and, as a result thereof, rotary movement without commutators, is of great and increasing importance in technical work.

In addition to these developments of alternating-current work we may in the future be able to note special applications of waves of different pitch superposed, and with various phasal relations. We have already telephone systems which depend on the superposition of waves of every pitch on the same system, and we may possibly look forward to other applications on a larger scale of similar superposed waves. The possibilities for future research in the alternating-current field are still great, notwithstanding the very important advances made within the past few years, many of which are still but little known, some remaining still buried in the patent office, while others are yet confined to the laboratory.

The purpose of this paper is to present in simple form the general characteristics of an alternating-current magnetic field as distinguished from the field of a permanent magnet or one produced by a steady electric current, and to point out the uses which can be made of the properties of the alternating field. The subject itself is so extensive that it will be impossible to be at all thorough in the consideration of phenomena so varied and oftentimes so complex. Experimentation is needed to convey a proper idea of the actions to which we shall allude, as well as to give a true understanding of their diversity. At the same time, the theory of the actions exhibited would require a graphical or mathematical analysis to render the account complete.

When an electric current is passed continuously in one direction through a single wire there is set up around the axis of the wire a magnetic field such that a piece of iron in proximity to the wire will have developed in it the peculiar magnetic state and will have north and south poles. If the current in the wire be in a direction away from the observer when the wire is viewed on end, the north pole will be directed in a path around the wire corresponding to the right-hand movement of the hands of a clock. If the current be reversed in direction, the magnetic relations or directions will be likewise reversed. In the same way, if the wire or conductor be coiled into a helix or spiral coil and a current be passed through it as before, a magnetic field will be produced around and through the coil such that a piece of iron wire inserted into the axis of the coil will become a magnet. If the magnet be viewed on end its north pole will be directed away from the observer when the current passes around in the same direction as the hands of a clock, and vice versa. This relation may be easily remembered in the phrases, "Right-handed direction of current, north pole directed away," "Right-handed direction of north polarity, current directed away." These statements, supplemented by their evident opposites for reversal of direction, "Left-handed direction of current, south pole directed away," and "Left-handed direction of north magnetism, current directed towards observer," are sufficient to give the key to very many magnetic and electric relations. It will be evident that if the current be intermittent the magnetic relations will be correspondingly so, and that an intermittent current will cause an intermittent magnetic field around a coil or conductor. If also the current be of the alternating character, reversing its direction many times per second, the magnetic field produced thereby will be of alternating polarity, or the direction of magnetic polarization will alternate. Such a field is an alternating magnetic field.

To intensify the effects of a magnetic field produced either by a steady, continuous current of electricity or by an alternating current, it is of course usual to employ an iron body or core, which, on account of its superior permeability to magnetic forces or susceptibility to magnetic excitation, gives much more intense actions than air. Just what constitutes the difference between substances which, like iron, are highly magnetic and others but little different from air or vacuum in this respect, is as yet quite unknown. There are, however, very decided differences between the magnetic fields produced by steady, continuous currents, and alternating magnetic fields. The former may be called passive, or static in character, while the latter may in truth be referred to as active, or dynamic, as will appear more definitely when reference is made to the actions producible therein. The passive or steady field has no action on closed metal bands placed in it except during the act of placing, while the alternating field has a very decided action of one kind or another.

Let us assume, then, that we have side by side good examples of apparatus, one of which furnishes us with a steady magnetic field and the other with an alternating field. It will suffice for this to provide for the first an upright iron bar of say two inches in diameter and ten inches long as our magnetic mass, and surround it by a coil of insulated wire having a continuous current sent through it. We cannot properly select such an iron bar for our magnetic mass in the second or alternating field apparatus, because we should find not only that the effects obtainable from it would be comparatively weak, but the core itself would rapidly get hot, owing to currents induced in its mass. Instead, therefore, we build up a wire bundle to the desired diameter, say two inches, by taking a great number of well-annealed soft-iron wires of ten inches length and about one-twentieth inch diameter. These wires are either varnished before being collected together or well scaled in the annealing. They are thus insulated from each other, at least sufficiently for our purpose. We surround this bundle or iron-wire core by a coil which is traversed by powerful alternating currents, changing their direction say 100 or more times per second.

We have now the means for comparing the effects of a steady magnetic field at the end of the iron bar with those of an alternating field at the upper end of the wire bundle. Let us bring a piece of steel or iron of some size successively into each field. In the steady field it is simply attracted, and if of hard steel is found permanently magnetized on taking it away. It is not otherwise affected to any appreciable degree. But in the alternating field it is less strongly attracted and intermittently, as is evident from the tremor or vibration, and it soon becomes hot. If of hard steel, such for example as a file, it may become so hot in a minute or two as to be incapable of being held in the fingers. Energy or work is evidently being expended on the piece, and this is abstracted from the source which keeps up the alternating current in the coil around the wire bundle. Substitute for the steel a bundle of very fine iron wires or sheets of very soft iron, and if these be presented on edge or in line with the field scarcely any heat is developed, but if the magnetic lines traverse the wires or sheets laterally the bundle at once heats.

We come now to consider a more decided difference between the two fields of magnetism—namely the action on closed bands or conductors, such as rings of copper, coils of wire with the ends joined, and plates, disks, etc., of metals which are good conductors for electric currents We may take, for example, a ring of copper or a round disk of the same metal, say four or five inches in diameter, and place it flatwise against the pole of the steady field magnet and it is not perceptibly acted on in any way, while if the same be done with the alternating magnet there will be noted a powerful repelling force exerted on the ring or disk such that even though it be of considerable weight it will be lifted and thrust off the pole. The writer discovered this action in 1886 and experimented at length upon it in many modified ways. If the ring be held down to the alternating pole or near thereto it rapidly gets warm. Indeed, with sufficient energy of alternating field a ring five inches in diameter made of copper wire ¼ inch thick may be made red hot and kept so in mid-air indefinitely. With care a ring may be made to float in mid-air over the alternating-magnet pole for a second or two, but the condition is one of very unstable equilibrium. It is made stable by tying strings to the ring so carried downward that the ring strains them upward in being lifted off the pole.

The cause of the actions of heating and repulsion in the experiments just noted may be readily understood. Even when the ring was put over the steady pole, there was in fact a resistance to its motion but only during the act of placing or while it was in motion. If the ring be brought very suddenly over the steady magnet, it will be vigorously held off. Owing to this fact it is found to be quite difficult to strike the pole of a powerful magnet by a thin flat sheet of copper brought down by the hand, even when the magnetism is steady.

The reason is that during the movement in the field a powerful current is induced or set up in the moving sheet which reacts on the field and distorts it, with the effect of a repulsive effort exerted in the sheet to keep the sheet away.

Similarly, if the sheet has been laid on the magnet pole and an attempt be made to suddenly remove it flatwise there will be found a strong opposing force exerted to retain the sheet or disk. In this case the currents induced by the movement are in a direction to cause attraction to the magnet. When the alternating field is used the currents which are induced in the ring or disk are opposite in direction to those which would produce the magnetic field itself and a repulsive effort is therefore exerted. To put it differently, the lines of force of the magnetic field in this case are opposed or distorted by the induced currents in the ring or disk. The reaction of these currents on the field producing them forces the ring or disk from the field. Hence, the alternating field is capable itself of heating conductors placed therein and of exerting mechanical force.

It would be out of place here to discuss fully the theory of the actions induced. It may be stated, however, that the fact that the current waves induced in the ring or disk by the alternating field are retained or lagged in virtue of their self-induction, from their true relation to the inducing field, is the cause of the repulsion. The alternating magnetism of itself would produce no repulsion were it not that the currents lag in the ring or disk so as to become virtually opposing or repelling currents, instead of equally repelling and attracting to the field. Rings of brass or German silver are much less powerfully acted on than those of the best conductors, such as copper and silver. Hence, for example, a real silver dollar is repelled energetically in the alternating field while one of a base alloy is hardly affected at all. This is owing to the relatively smaller currents induced in the poorer conductor, as well as to the fact that the currents are not retarded or lagged sufficiently for the maximum effect. Let us substitute a coil of wire of many turns insulated from each other, for the ring in the repulsion experiment. In the steady magnetic field there is no effect, but in the alternating field there are waves of current induced such that an incandescent lamp connected to the terminals of the coil may be lighted when the coil is brought into the alternating field. Its brightness will vary with the position of the coil with relation to the lines of force and their density. The maximum effect will be when the whole of the alternating field is enclosed by the coil. As the coil is lifted away the brilliancy of the lamp serves as a rough measure of the reduction of the intensity of the field, or rather of its inductive action at a distance. Indeed, we may take advantage of the arrangement just referred to for securing a constant illumination of the lamp or a constant current in its circuit, by hanging the coil in the field to a scale-beam and so loading the same that the coil will have a definite tendency or weight tending to move it into a stronger portion of the field. This is counterbalanced by the repulsive action exerted on the coil so that the latter floats, as it were, in such a strength of field as will induce a definite current. Variations of the field, or the alternating current which produces such field, are compensated at once by an automatic adjustment of the coil in relation to the field.

This apparatus will undoubtedly be found useful in photometry for maintaining a standard current through a lamp. A very pretty modification of the experiment is that of the "floating lamp." A small coil of wire has attached to it a suitable incandescent lamp and is waterproofed so as to allow immersion in water in a glass vessel placed over the alternating magnetic pole. The lamp and coil are so loaded that they freely sink when no alternating field is present. The putting on of alternating current so as to produce a powerful field causes the lamp to rise or float upward with its attached coil to a height such as will maintain a certain brilliancy and at the same time cause a balance to exist between the uplifting repulsion of the coil in the field, and its tendency to sink. Here, then, we have a lamp lighted under water without apparent connection with anything and maintaining a constant degree of illumination while floating, not at the surface, but in the body of the liquid. The insertion of a copper sheet between the glass vessel and the alternating pole screens or cuts off the effect to a large extent.

This brings us to another phase of the subject, for if, in applying the screen in the last experiment, we place it so that it only covers a part of the alternating magnet-pole, it will be seen that the lamp-coil is moved laterally so as to tend to place itself directly over the screening piece. If we now substitute for the lamp-coil a plain ring placed over the copper screen so as to be free to move, it will slip over the screened portion of the pole as if attracted thereto. Indeed we may take two rings of copper and place them together in the alternating field. They will attract each other and, if of equal diameter, will lie parallel as one ring. The double ring will now be repelled from the pole as if it were a single ring. The explanation of the attraction of the two rings is simple. Both are under the same induction and currents are set up in both which are in the same direction at all times. Currents in the same direction produce attraction of the conductors conveying them into parallelism and as near together as possible.

By utilizing this principle we are enabled to secure continuous movements as of rotation around an axis—for we have only so to dispose conducting metal that it shall continuously be attracted towards our metal screen. Placing then a screen or shading-plate over the alternating-magnet pole so as to cover it only in part, we approach the edge of a disk of copper pivoted centrally and free to rotate, so that one side of the disk shall cover the "shaded" pole. It at once begins to revolve and soon rotates rapidly, the movement being such as to bring new portions of the rotating disk constantly over the screen. The phenomenon in reality depends on shifting magnetic fields. The shading-piece or screen retards the development of the alternating polarities in the space near it, while there is no retardation over the unshaded or unscreened portion of the end of the wire core. The effect is the same as if the magnetism continually traveled or shifted from the clear part of the pole to the shaded or screened part. But lines of force in movement will push conductors with them, and so the disk subjected to such influence is driven continuously. If an iron or steel disk be mounted on pivots, it will also be driven over the shaded pole, but its plane of rotation should be at right angles to that of the copper disk. Both disks may be driven together in planes at right angles. The iron disk is driven by the shifting lines of force as if it were pulled around by a magnet. One copper disk may act as a screen for another and both be set in rotation if they are suitably placed. Similarly, copper and iron disks may react on each other and both be set in rotation. Indeed, it is possible to keep a number of copper and iron disks in rapid rotation by placing them suitably in a single alternating magnetic field. Pieces of steel, tubes of copper, lumps of brass, iron masses, placed in an alternating magnetic field so modify it as to cause shifting magnetism, such that rotations are produced in pivoted iron and copper disks placed near them. An almost endless variety of dispositions may be selected and the results correspondingly varied. Thus the simple placing of a steel file acoss the alternating pole gives rise to shifting lines of force starting at the pole and passing to the ends of the file. Pivoted iron and copper disks placed near the file are rotated accordingly. Magnetic fields may be caused to travel around iron rings, along copper tubes, over sheets, etc., in each case being detected in their movement by the tell-tale rotating disks. The best detector is a delicately-mounted iron disk made up of several round punchings of sheet iron, and provided with an overhanging rim of copper, thus resembling an iron pulley with a wider rim of copper.

We thus see that an alternating magnetic field is truly dynamic in that it not only actively repels closed circuits or deflects them into positions parallel to the lines of force in such field, but also that the introduction into the field of such a simple thing as a piece of conducting metal, or a piece of magnetic substance, brings about laterally traveling or shifting lines of force which may confer rotation or movement even continuously to pivoted pieces of conducting or magnetic metal.

That these principles should fail to find practical applications would be extraordinary. Indeed, the fact is that they are applied in practice in many ways the details of which would be out of place in the present paper. They have been utilized in constructing regulators for alternating currents, arc-lamps, and for self-starting alternating current motors, as well as in the construction of meters for registering the consumption of energy on alternating circuits.

One of the most curious facts brought out in the course of experimentation, an outline of which has been given above, was that a structure of copper and iron, such as the iron disk or pulley with a copper rim, when once set in rotation in an alternating magnetic field, would not only continue in rotation, but increase its speed up to a certain point, even though there existed no shading-piece nor other device in the field to set up shifting lines or traveling field. The copper-rimmed wheel was sufficient unto itself after it was first started in rotation. Similarly, an armature of laminated iron bearing closed coils or circuits on its exterior and placed in an alternating field will, after starting, continue its rotation. Not only that, but with a scientifically-constructed machine the tendency to rotate will not be easily checked by taking power from such armature. This machine is in brief the single-phase induction worked up to a fair degree of perfection in late years. By the employment of commutators which only act during starting or by embodying the principle of the shaded pole, these machines become self-starting in character even under load.

It has of course required a very large amount of careful, painstaking effort to apply the principles pointed out to the actual commercial needs. This is particularly the case where the machinery has been required to reach a high standard of excellence. Much work will be accomplished in this field in the near future

While, properly speaking, no account of the properties of an alternating magnetic field would be at all complete without a discussion of those particular phenomena which are produced by currents of differing phasal relation acting on the same magnetic medium, we must at present pass them by Otherwise we would be led into a field of work which may well be set apart as special, involving the consideration of the effects of polyphase currents, together with the machines which employ them and which have taken a very important place in power-transmission within the past few years. Neither can we discuss, within the limits of the present paper, the remarkable effects produceable in an alternating magnetic field of high frequency. Such fields are capable of inducing hundreds of volts to the inch of conductor, may even induce currents in a person's body such that an incandescent lamp may be fully lighted if the terminals be taken in the hands, or give rise to electric discharges which will leap distances in air of over five feet. These discharges resemble lightning discharges closely, not only in appearance, but in their destructive effects in overcoming obstacles in the path, yet they are comparatively less harmful to life than our more ordinary electricity at relatively very small pressures or potentials.

It may be said in conclusion that the study of alternating currents and, incidentally thereto, of the magnetic effects of such currents, has widened the field of electric possibility almost without limit, and that there are at present no signs of abatement of progress in the directions given to electrical research thereby.

Furthermore, the study of the interactions occurring between what may be termed energy storage in an alternating magnetic field and energy storage in electro-static fields, is leading the way to the solution of many great problems. The combination together of the effects of inductance, or magnetism in a circuit with capacity, or electro-static induction, is indeed the field of work which has promise of great results in the future.

DEVELOPMENT OF THE ELECTRIC LOCOMOTIVE.

By B. J. Arnold, M. Am. Inst. E. E.

THE electric locomotive is but one of the many applications of the electric motor. But its early development is so closely allied to that of the motor that it has been thought well to embody in this article a brief history of the latter, drawing attention only to those machines which have marked a decided advancement in the art or such as were applied to the propulsion of cars.

To an Englishman named Barlow belongs the credit of performing (in 1826) the first recorded experiment involving the principle of the electric motor, by illustrating how electricity could be employed as a motive-power by rotating a disk of copper between the poles of a permanent magnet. To Italy, however, must be ascribed the honor of having first excelled in this most interesting scientific field, by producing what is believed to be the first electric motor. In 1830 the Abbé Salvatore Dal Negro, a professor of natural philosophy at the University of Padua, invented a reciprocating form of motor, so arranged that a permanent magnet oscillated between the poles of an electromagnet, the polarity of the latter being changed at each oscillation.

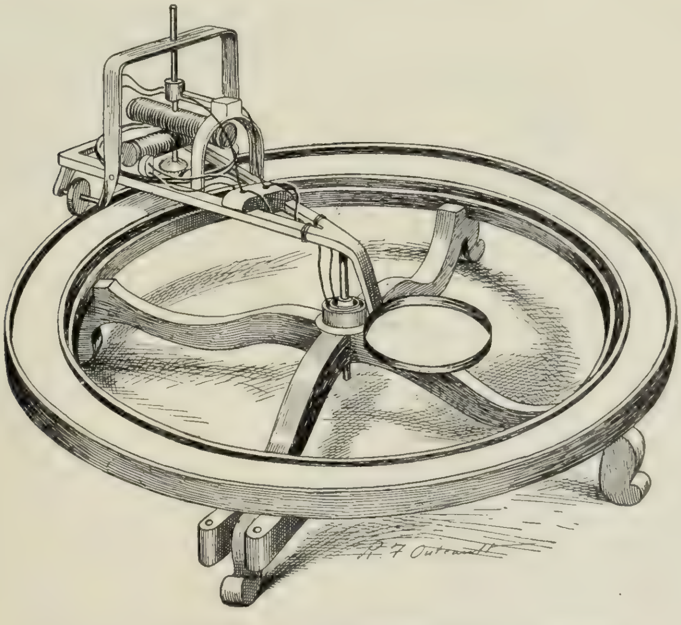

FIG. I—DAVENPORT'S ELECTROMAGNETIC MOTOR.

Thomas Davenport, a blacksmith of Brandon, Vermont, devised in 1835 a motor consisting of a revolving electromagnet, the poles of which were attracted by fixed magnets in which the current was broken or commutated at suitable intervals, so as to attract or repel the magnets of the revolving portion. This device, but little more than a scientific toy, was driven by primary batteries, and was exhibited in operation the same year at Springfield and Boston, Massachusetts, being the first practical demonstration of an electric car on record.

In 1838, Robert Davidson, of Aberdeen, Scotland, constructed an electric car or locomotive, about sixteen feet long, driven by forty primary cells, which weighed, complete, about five tons. Several trips were made with this on the railways of Scotland with great success. It was eventually destroyed by some miscreant, supposed to be a jealous steam-engineer fearful that this apparently formidable rival might render his calling obsolete.

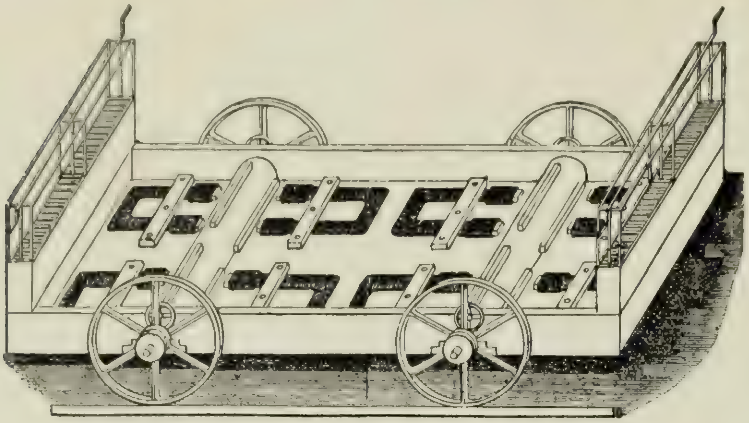
FIG. 2—ROBERT DAVIDSON'S ELECTRIC CAR.

Our own countryman, the late Moses G. Farmer, whose investigations in electricity extend over a wide field, constructed in 1847 an electromagnetic locomotive which was driven by primary batteries, and drew a little car carrying two passengers, on an 18″ gage track. During the same year a Mr. Lillie and Dr. Colton of Pittsburgh, Pennsylvania, built an electric locomotive driven by primary cells and operated it on a circular track. In 1850, Professor C. G. Page, of the Smithsonian Institution, constructed an electric locomotive and ran it from Washington to Bladensburg, a distance of five miles, upon the standard-gage track of the

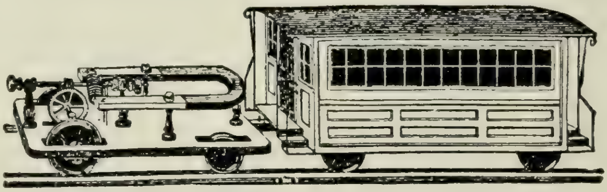
FIG. 3—MODEL OF HALL'S ELECTRIC LOCOMOTIVE.

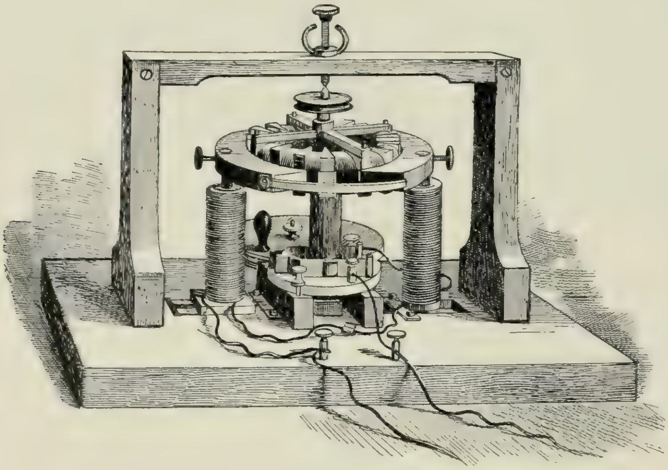
FIG. 4—PACCINOTI'S MACHINE.

Washington and Baltimore road. It was rated at 16 horse-power and employed one hundred cells of nitric-acid battery to drive it. It attained a maximum speed of nineteen miles per hour, but was abandoned on account of the excessive cost of operation.

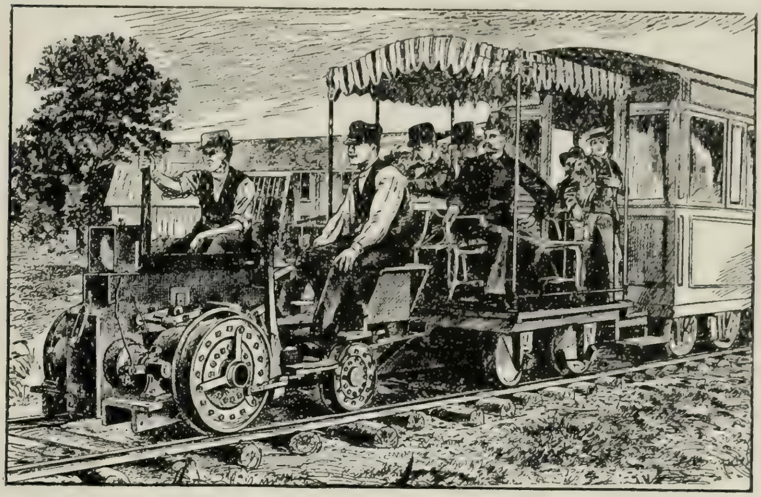

FIG. 5—EDISON'S EARLY ELECTRIC LOCOMOTIVE.

Contemporaneous with Page's experiment, Thomas Hall, of Boston, built and exhibited a small model of an electric locomotive illustrated on p. 540. The motor consisted of a permanent magnet, between the poles of which revolved an electromagnet, its armature being geared to the axle of the car. All these early inventions of electric cars and proposed electric locomotives were non-productive of commercial results, for the reason that the inventors were entirely dependent upon primary batteries as the source of power, and it was not until 1861, when Paccinoti, the distinguished Italian physicist, made his famous electromagnetic machine, the nucleus of the modern dynamo and electric motor, that the possibilities of the electric railway and power-transmission schemes of the present day were made possible. This machine is shown in Fig. 4. It was described in the Italian journal *Il Nuovo Cimento* in June, 1864, but it was not until 1871, when Gramme brought out his dynamo with the ring armature,

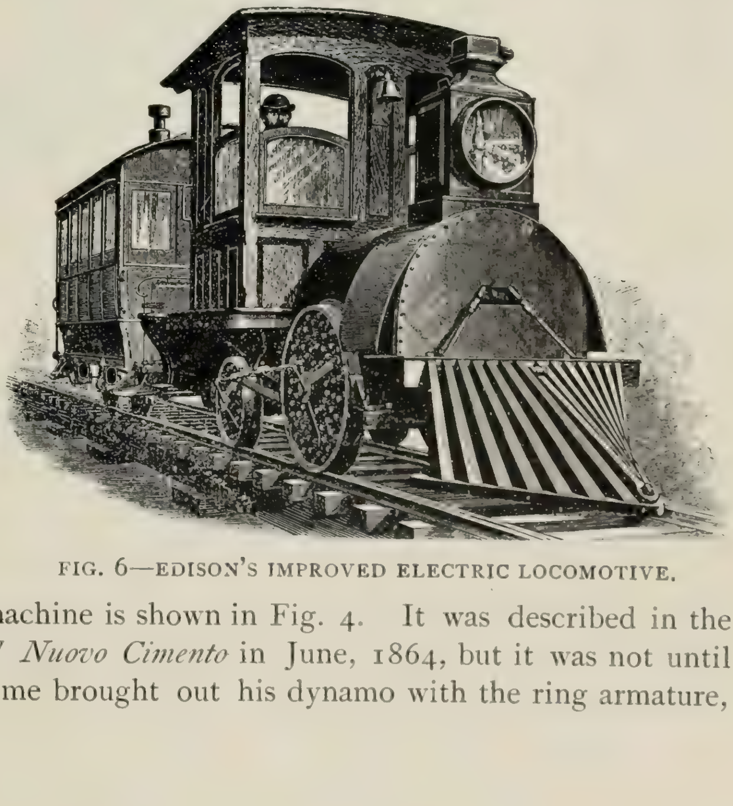

FIG. 6—EDISON'S IMPROVED ELECTRIC LOCOMOTIVE.

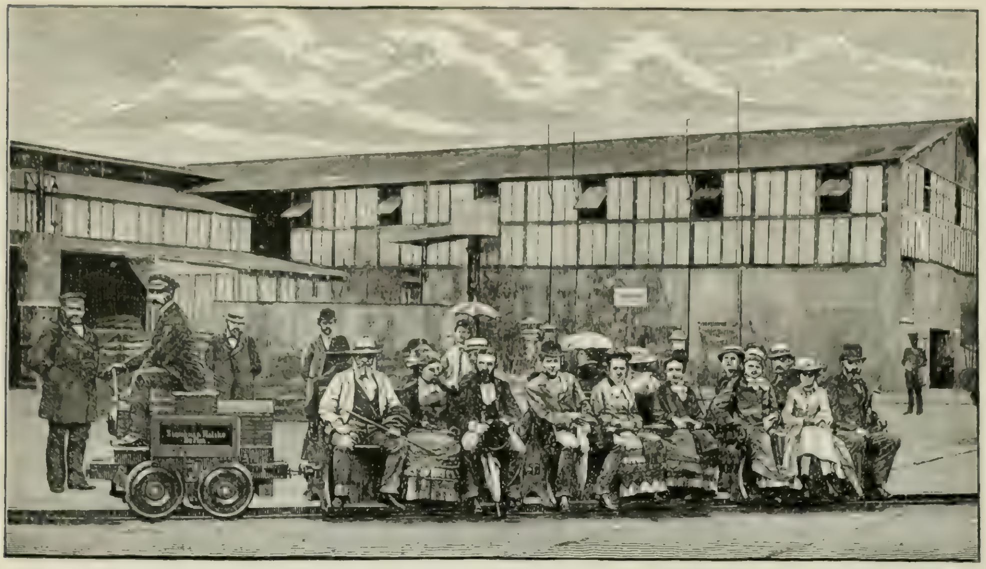

FIG. 7—SIEMENS'S ELECTRIC LOCOMOTIVE, EXHIBITED AT BERLIN IN 1879.

that Paccinoti realized the worth of his own invention, and resurrected it from the museum of the University of Pisa, exhibiting it at the Vienna exhibition of 1873 and the Paris exhibition of 1881. The dynamo was proved conclusively to be applicable as a motor, by Fontaine and Breguet, on June 3, 1873, in Machinery Hall, at the Vienna exhibition. They had intended to install their plant so as to run one dynamo as a motor from a battery, but, owing to the failure of the power, they coupled the two machines together, thus driving one of the dynamos as a motor from the other. From this date the development in all branches of electrical machinery was rapid and from this forward we will confine our attention to the electric locomotive, or railway part of the electrical field.

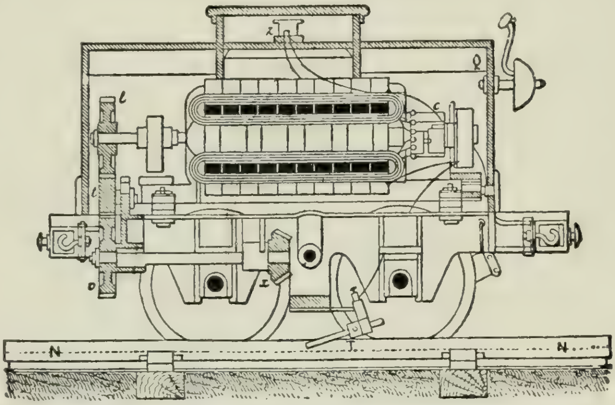

FIG. 8—SECTION OF SIEMENS'S LOCOMOTIVE.

In 1875, George F. Green, of Kalamazoo, Michigan, constructed a small electric car similar in many respects to Farmer's, although somewhat larger. He used the track-rails to convey the current to the moving car, batteries being used for power and small electric motors of the pole-changing type for the propulsion of the car. His drawings also show that he proposed to use an overhead wire as one of the sides of the circuit. He worked assiduously at the development of his ideas and in 1878–79 built a model large enough to draw two people. He fully understood the advantages of having a dynamo, but none was available, and, as is often the case, poverty prevented him from making application for patents until August, 1879, when, acting as his own patent attorney, he encountered difficulties in the patent office which caused the rejection of his claim. His case was afterwards tried before the circuit court of the District of Columbia and a patent was granted, although this did not come until December, 1891, shortly before his death. The legal ownership of his patents had long since passed out of his possession and it would thus seem that, through poverty, misfortune, and the shortcomings of the patent office, he was deprived of a patent, which, had it been granted at the proper time, might have made his name one of the best known among electric-railway inventors of America, as his experiments seem to form the bridge between the impractical and the practical in electric-railway work.

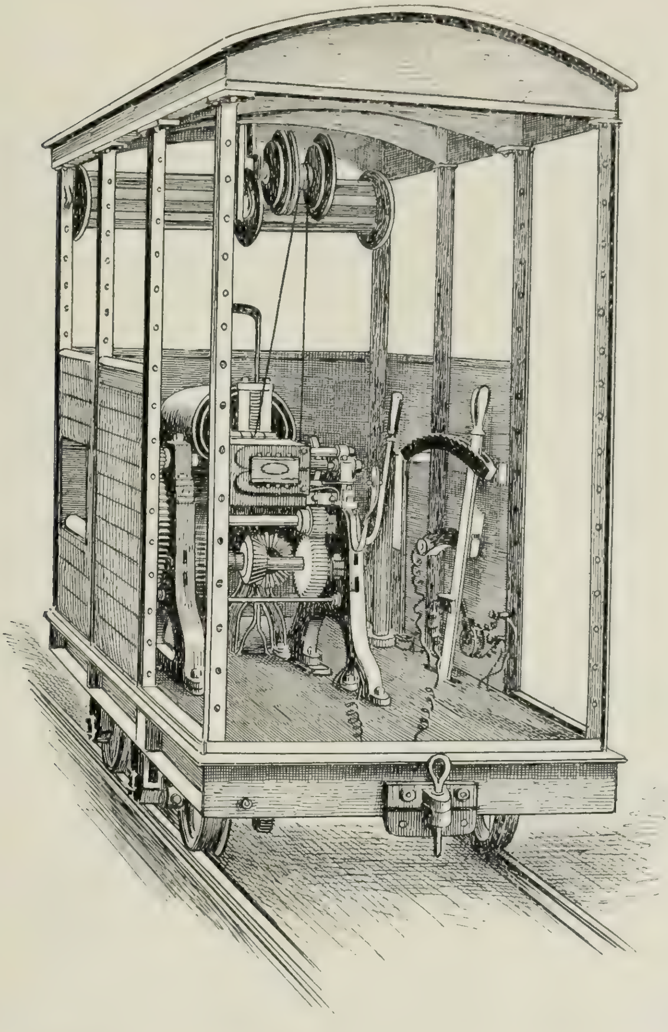

FIG. 9—LOCOMOTIVE DRIVEN BY ACCUMULATORS, LISIEUX, FRANCE.

On May 21, 1879, Stephen D. Field filed a caveat for a patent on an electric railway, which was afterwards granted, although in 1880 Thomas A. Edison had brought out the first practical working electric-railway locomotive in the United States. The interests of Edison and

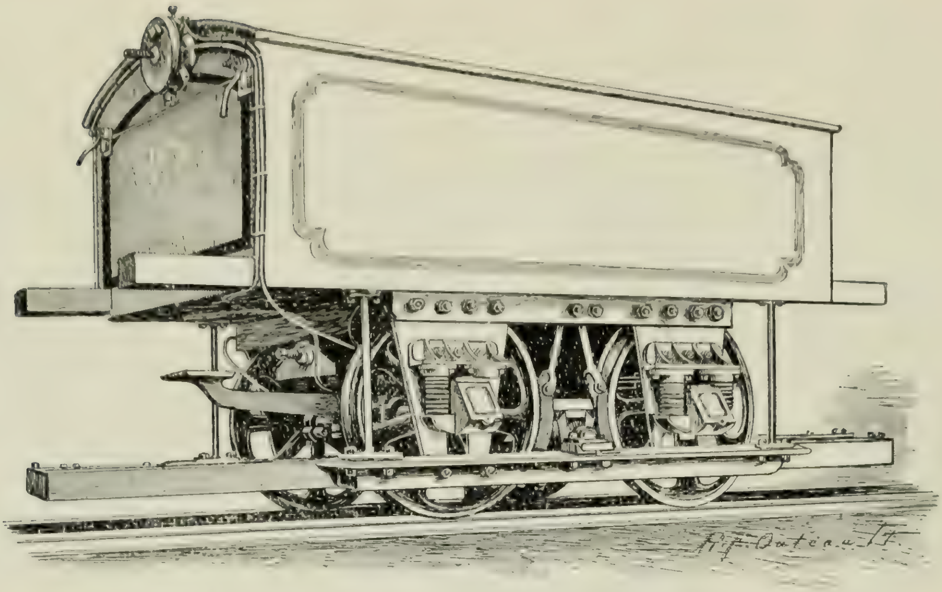

FIG. 10—RECKENZAUM'S MINING LOCOMOTIVE.

Field were in litigation in the patent office for a number of years, the case being eventually decided in favor of Field, but not until after the warring factions had been brought into the same financial fold. The Edison locomotive was driven by a motor connected to the forward axle by a belt, the electricity for the propulsion being obtained from a dynamo similar in design to the motor. Figure 6 shows the Edison locomotive after it had been improved.

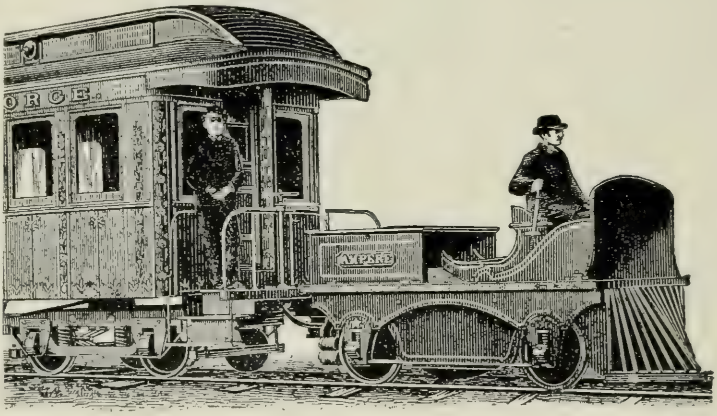

FIG. 11—DAFT ELECTRIC LOCOMOTIVE "AMPERE."

Simultaneously with the work of Field and Edison in America, Siemens, of Germany, who was practically the originator of electric-railway traction abroad, built and exhibited at the industrial exhibition at Berlin, 1879, an electric locomotive which operated a small train of cars upon an oval track about 1000 feet in circumference. Referring to Figure 8 it will be noticed that the armature of this locomotive was mounted parallel with the rails, power being transmitted to the axles by gearing.

While the locomotives driven by means of dynamos and primary batteries were being produced, the storage-battery advocates for elec-

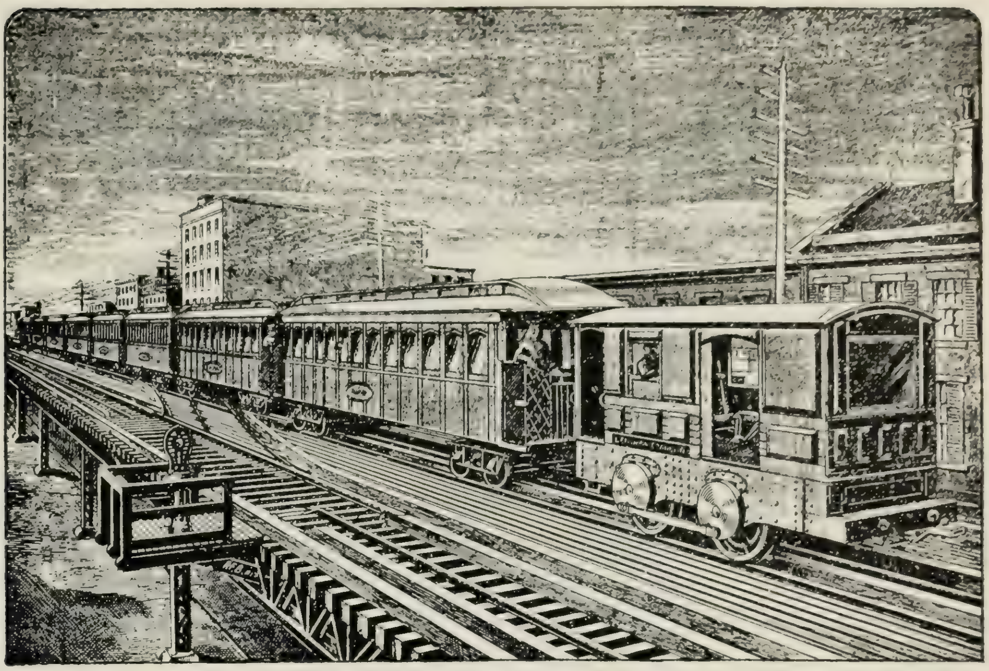

FIG. 12—THE "BENJAMIN FRANKLIN," WITH A TRAIN OF EIGHT CARS.

tric traction were also busy, and during the year in which Siemens produced his model road, a storage-battery locomotive was built and brought out at the linen-bleaching establishment of M. Duchesne-Fourmet, at Breuil en Auge, France (Figure 9). The track was about a mile long and electricity was adopted as the motive-power for the reason that the fabrics to be bleached had to be sent from the factory to the bleaching-fields, and the soot and smoke attendant upon the use of a gas-engine or steam-engine would have been injurious.

Storage - battery cars were tried in almost all the leading cities in Europe

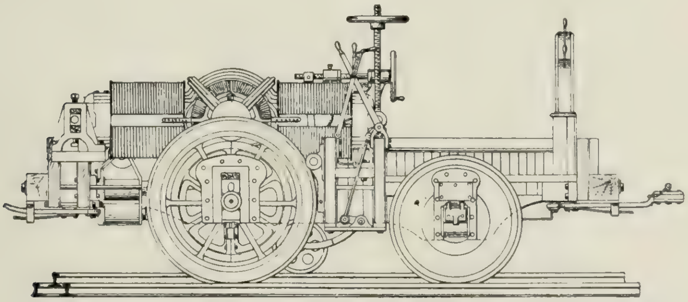

FIG. 13—SIDE ELEVATION OF THE ABOVE.

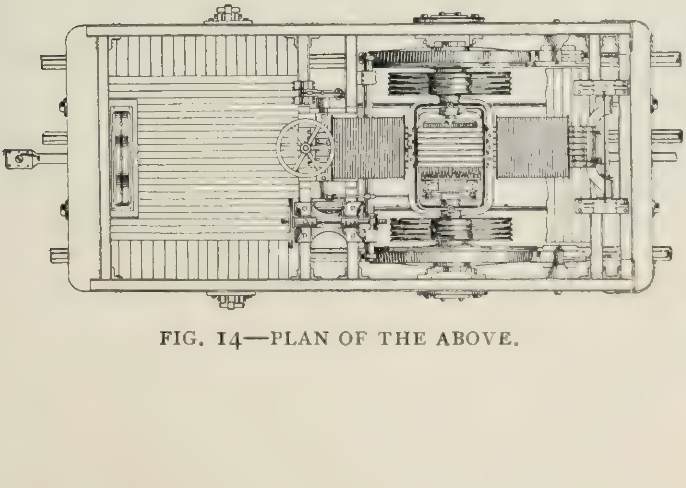

FIG. 14—PLAN OF THE ABOVE.

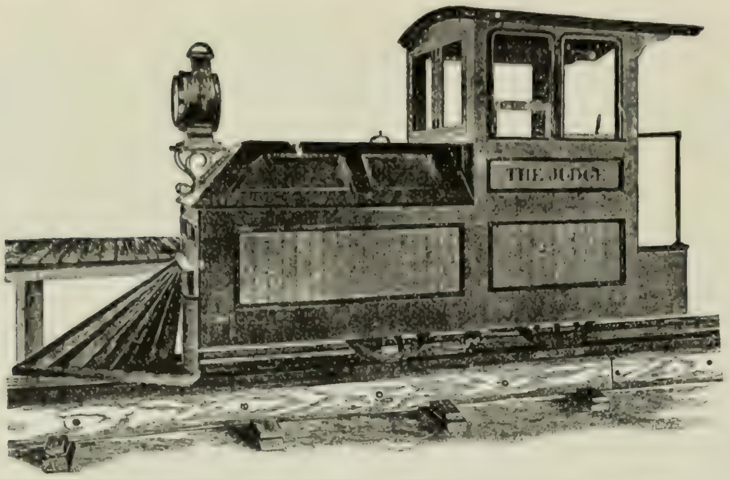

FIG. 15—"THE JUDGE," OPERATED IN CHICAGO IN 1883.

and the United States, between the years 1879-84, but as they were mostly modifications of the ordinary street-car, they would not be classed under the head of electrical railway-locomotives, and illustrations and descriptions are therefore omitted here. One notable example (shown in Figure 10), designed and built from plans of the late Anthony Reckenzaun, an Austrian whose investigations in the electric traction field were extensive, and did much toward solving and bringing into successful operation the electric railway system of the present time, will serve the purpose of this article. This locomotive developed about 8 horse-power and was used for hauling coal in the Trafalgar collieries of England, operating upon an extremely difficult track, having a gage of 2′ 7″, with many grades and sharp curves.

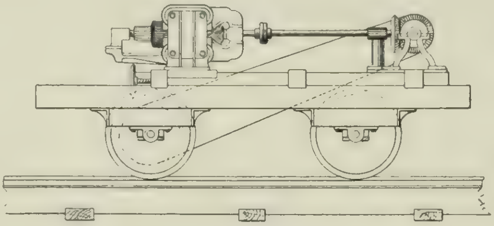

FIG. 16—SIDE ELEVATION.

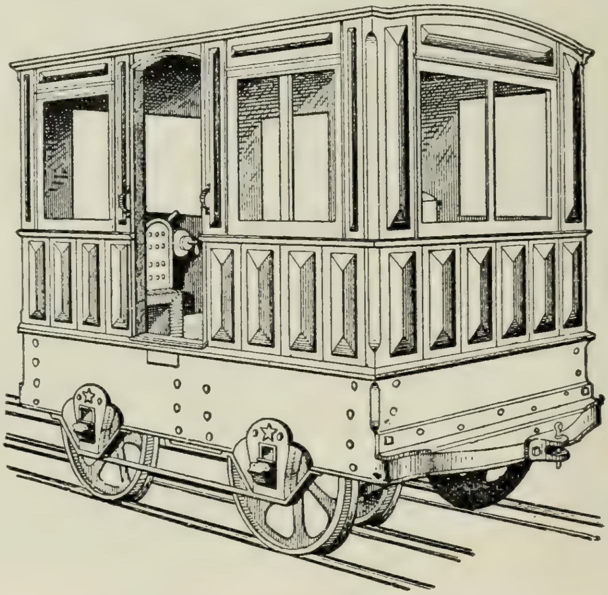

FIG. 17—"THE MORSE," OPERATED IN 1885.

In 1883 Leo Daft, an Englishman by birth, built an experimental electric railway at Greenville, New Jersey, and a little later operated, on the Saratoga and Mt. McGregor railway, a locomotive called the "Ampere." This machine was ten feet in length, weighed about ten tons, and attained a speed of eight miles per hour up a grade of ninety-three feet to the mile. Current was supplied by means of a third rail.

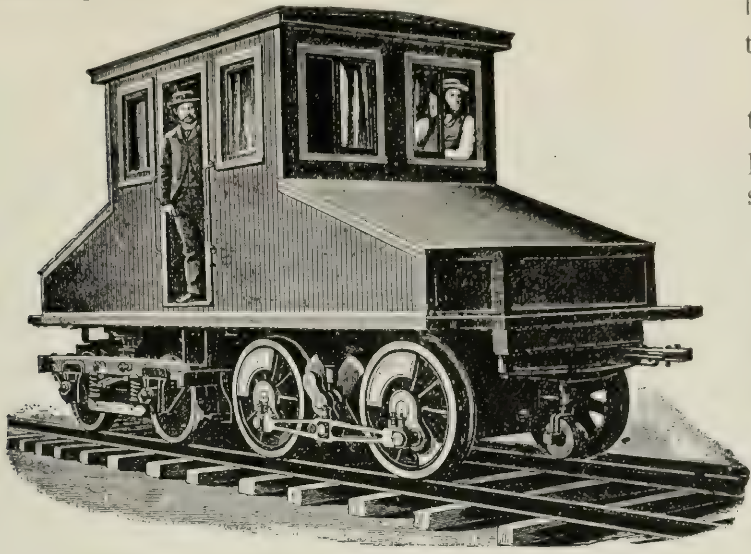

FIG. 18—FIELD'S ELECTRIC LOCOMOTIVE.

Mr. Daft continued his experiments for some years following, his most important work being the experiments in 1888-89 upon the elevated railway in New York, where he operated the "Benjamin Franklin," shown in Figures 12 to 14. It was about fifteen feet in length, weighed nine tons, and, although designed for 75 horse-power, devel-

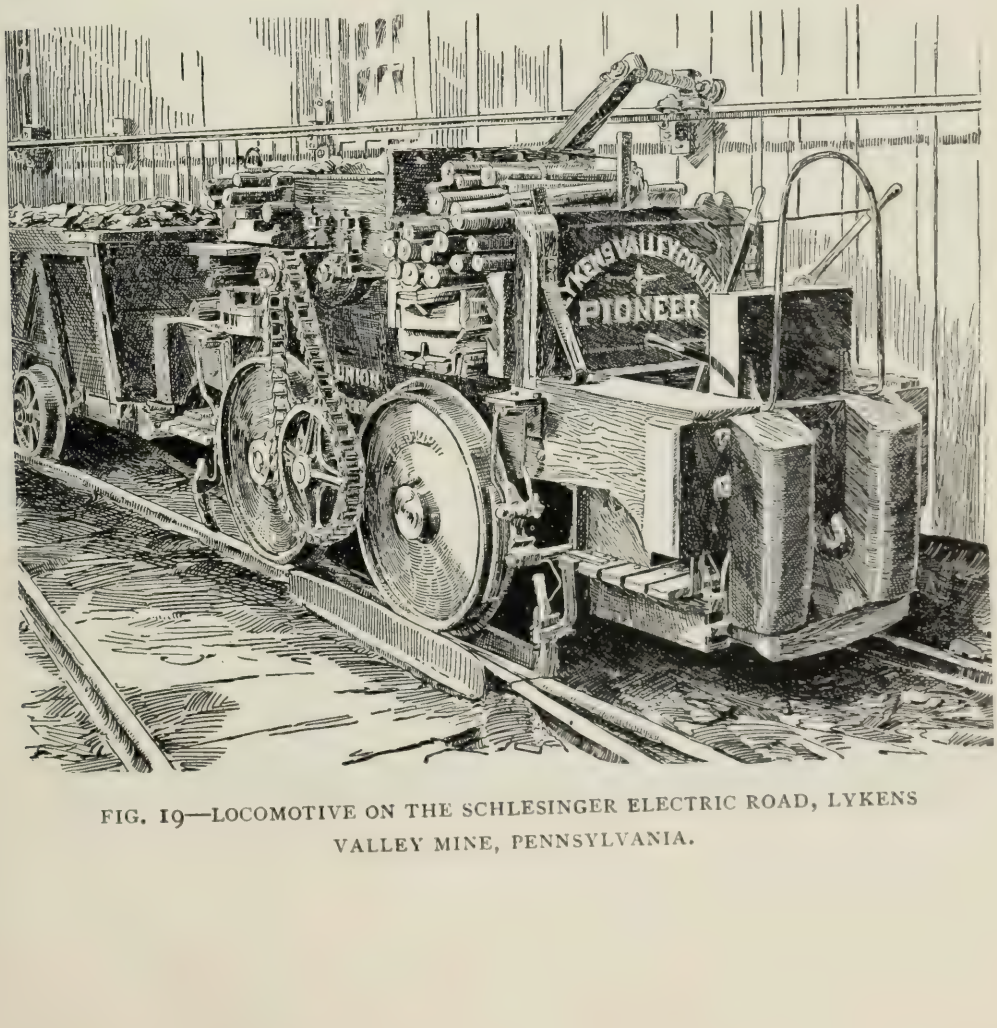

FIG. 19—LOCOMOTIVE ON THE SCHLESINGER ELECTRIC ROAD, LYKENS VALLEY MINE, PENNSYLVANIA.

oped at times as high as 120 horse-power when hauling an eight-car train up a 2-per-cent. grade at 7½ miles per hour. The plant for producing the power being crude and uneconomical, and the motor too light for the work, the experiment was abandoned, thus giving the impression to the railway world that electricity for operating railway trains was much more expensive than it afterwards proved to be. At the Chicago Railway Exposition, in 1883, was constructed the first electric railway built in this country for busi-

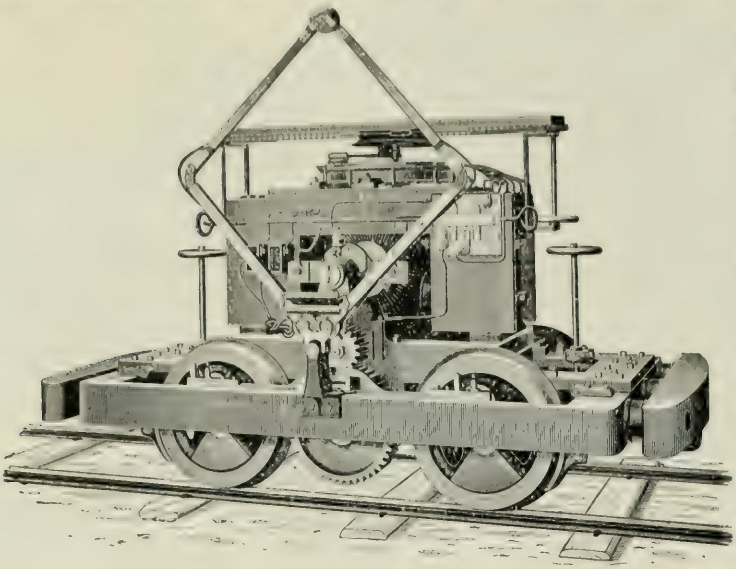

FIG. 20—MINING ELECTRIC LOCOMOTIVE.

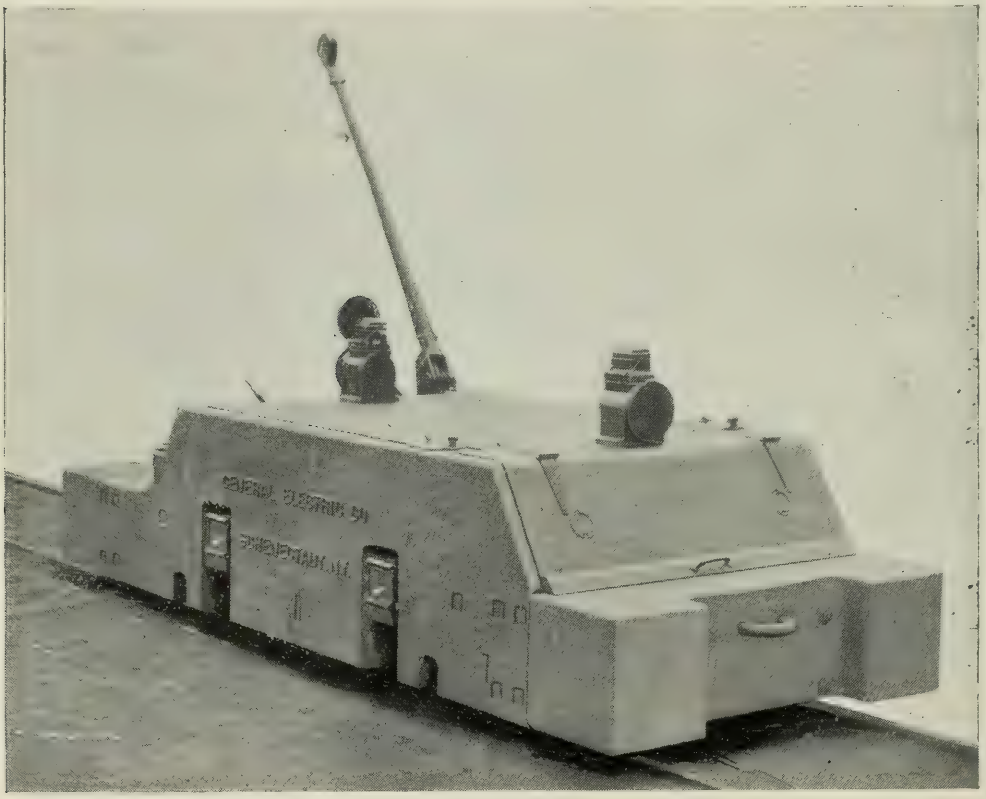

FIG. 21—ELECTRIC MINING LOCOMOTIVE.

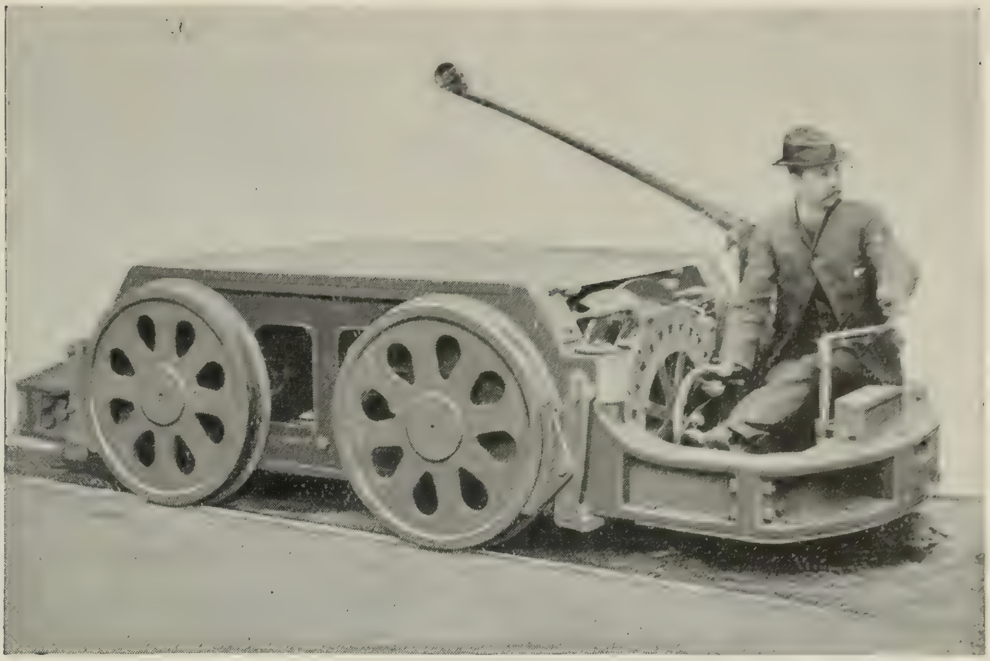

FIG. 22—TWO-MOTOR MINING LOCOMOTIVE, WITH OUTSIDE WHEELS.

ness purposes. This was the first public demonstration of the utility of electricity for railway work, it being the forerunner of the elevated electric road in this country, the culmination of which was realized in the Intramural road at the World's Fair in 1893.

The locomotive (illustrated in Figures 15 and 16) was called the "Judge," and consisted of a platform car about twelve feet over all, supported by four wheels. Upon the platform was mounted a Weston dynamo, the power of which was transmitted to one of the axles by means of beveled gearing and a belt. It was designed by Stephen D. Field and placed in operation by the Electric Railway Company of the United States, which at that time controlled the patents of both Edison and

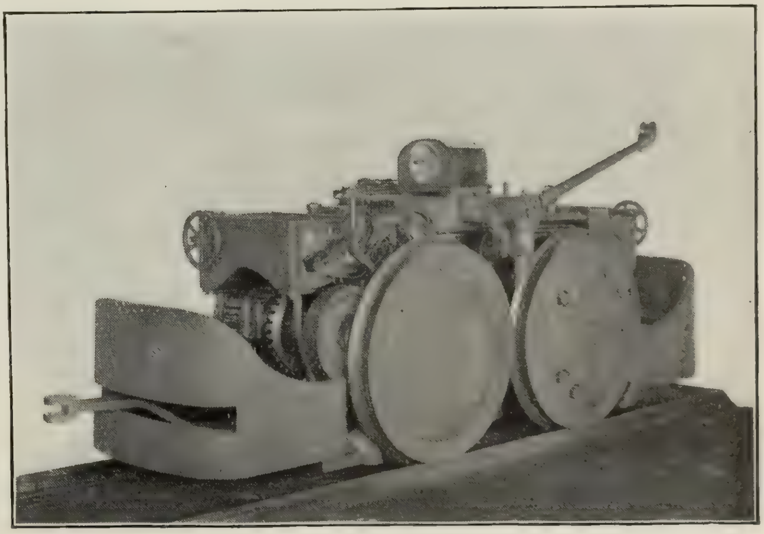

FIG. 23—"INDEPENDENT" ELECTRIC MINING LOCOMOTIVE.

Field. It weighed about 2700 pounds and operated upon a circular track about 1500 feet in length, having a 3′ gage, and carried during the exposition about 27,000 passengers. Electricity now began to attract the attention of many minds and the inventions and experiments in the electric-railway field became so numerous that it is impossible to catalogue them all, and only the most noted trials and achievements will be spoken of.

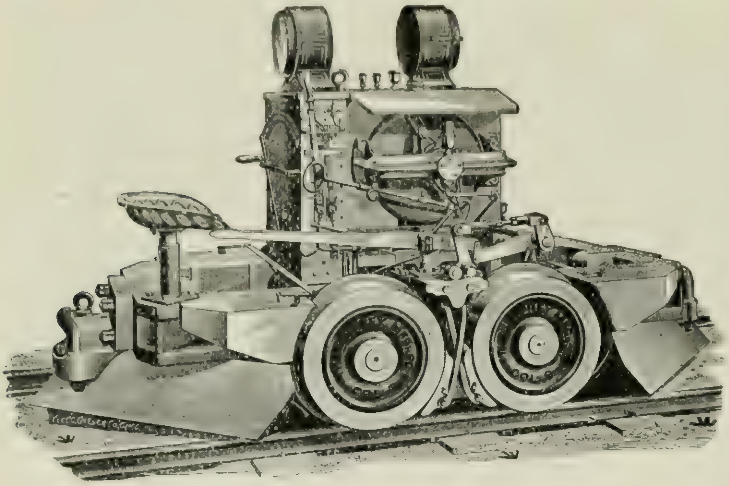

FIG. 24—JEFFERY ELECTRIC MINING LOCOMOTIVE.

The "Morse" and its counterpart, the "Faraday," were brought out by Daft in 1885, for use on the Baltimore Union Passenger railway. The former (shown in Figure 17) was 12½ feet long by 7½ feet wide and weighed 4200 pounds. Figure 18 illustrates one of Mr. Field's locomotives which he constructed and put in service upon the Thirty-fourth street branch of the New York elevated railway. It will be noticed that the motor is mounted midway between the wheels and directly connected to them by means of side-rods similar to the ordinary steam-locomotive. The series motor was controlled by a liquid rheostat. It was mounted upon 36-inch wheels and weighed about thirteen tons.

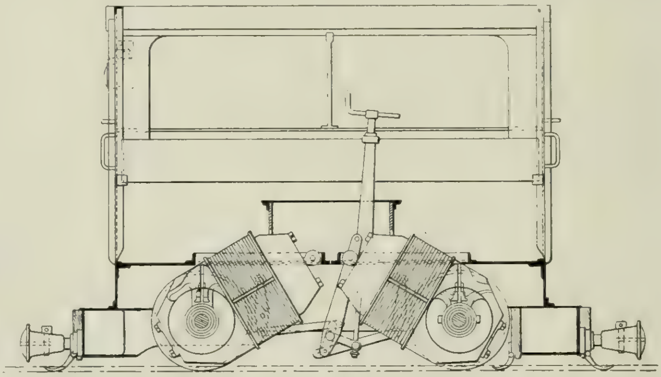

FIG. 25—ELECTRIC LOCOMOTIVE ON CITY AND SOUTH LONDON RAILWAY.

Extensive experiments were also carried on on the Thirty-fourth-street line by Frank J. Sprague, who, in conjunction with Charles J. Van Depoele, may be considered the most successful pioneer in the application of electricity to the propulsion of cars on the surface street-railways in America.

From the time of the abandonment of the experiments by Daft,

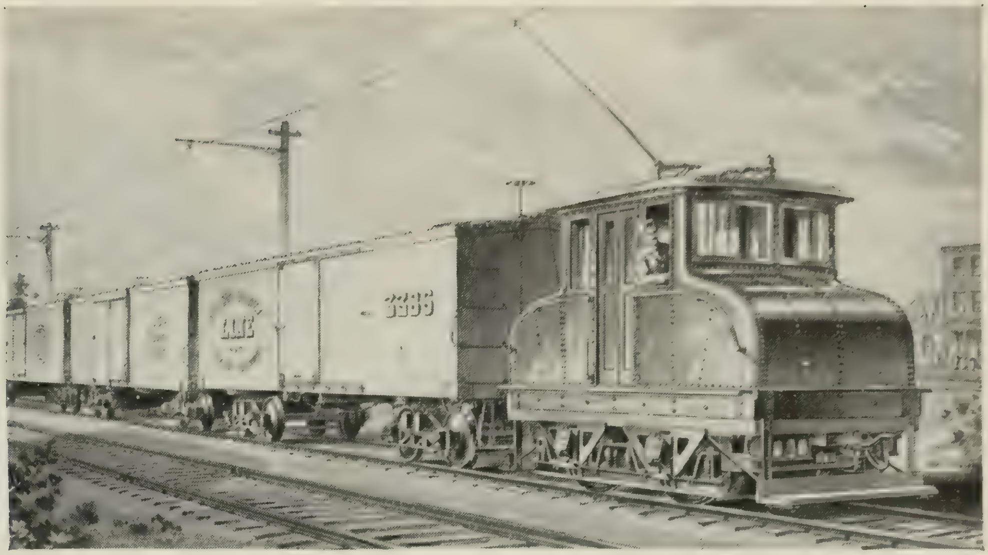

FIG. 26—THIRTY-TON LOCOMOTIVE DESIGNED FOR ELEVATED SERVICE.

Field, and Sprague, the attention of inventors was directed toward the application of electricity to street-railways, and the best testimonial that can be given to their genius and indefatigability is the fact that there are to-day in operation, in the United States alone, over 8000 miles of electric railway, using 18,000 cars, involving an investment of more than $80,000,000.

The application of electric locomotives to mining work in America was inaugurated July 26, 1887, at Lykens, Pennsylvania, by W. M. Schlesinger, with a locomotive designed by him and illustrated in Figure 19. It operated successfully at a speed of six or eight miles per hour, hauling trains weighing from 50 to 100 tons, increasing the capacity of the road to three times its former

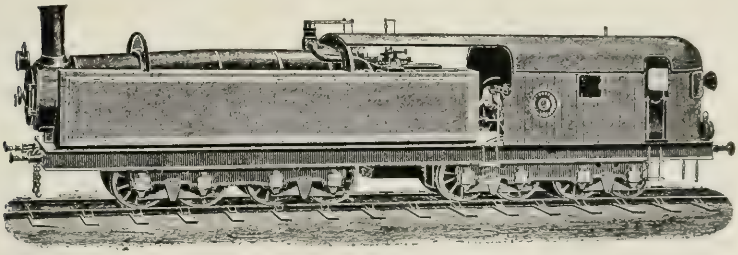

FIG. 27—HEILMAN ELECTRIC LOCOMOTIVE.

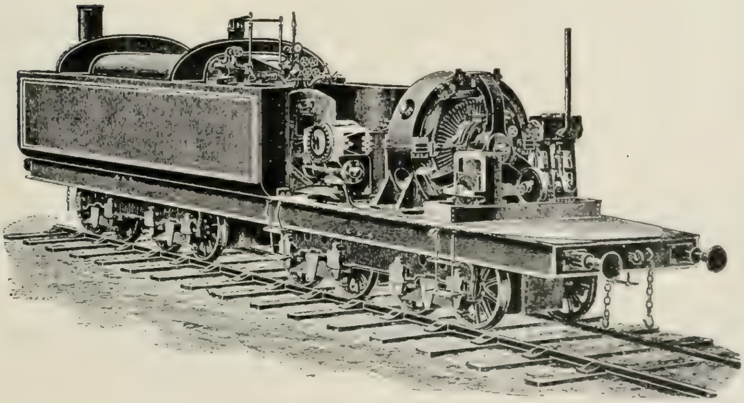

FIG. 28—HEILMAN ELECTRIC LOCOMOTIVE.

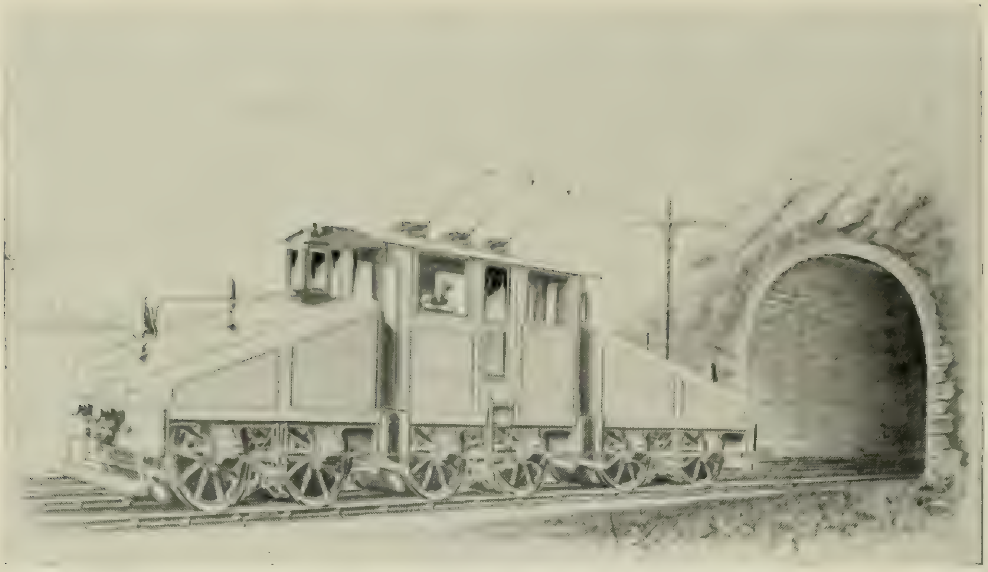

FIG. 29—ELECTRIC LOCOMOTIVE FOR FREIGHT AND PASSENGER TRAINS IN THE BALTIMORE AND OHIO TUNNEL.

output with animal power. The mining industries seem to offer the best inducement for the application of electricity to haulage, with the exception of the surface street-railways, which has resulted in the rapid development of this class of electric locomotives. Figures 20 to 23 show types of the various mining locomotives now built by the leading manufacturers of this class of machinery. The United States are now dotted with many plants in which this silent and invisible power is doing duty in place of the faithful mule, and lessened the cost of haulage from 30 to 50 per cent.

Figure 25 shows a locomotive of the City and South London line, which has now been in operation for about two years with most excellent results. These locomotives are in daily operation, hauling forty-ton trains, at an average speed of 13½ miles per hour, through subterranean caverns in which it would be impracticable to use any other form of power, at an expense of 13 cents per train mile, making the cost per passenger less than with steam-power when the relative weights of trains are taken into consideration.

Figure 26 shows a thirty-ton locomotive designed for elevated

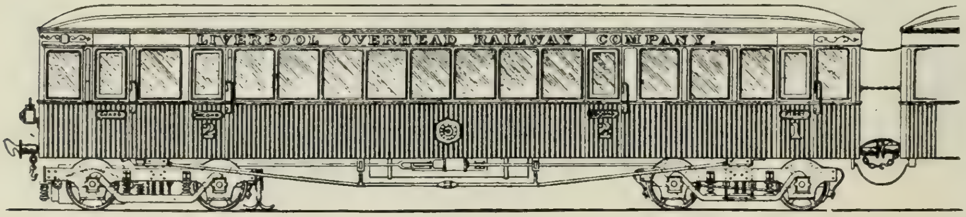

FIG. 30—LIVERPOOL OVERHEAD RAILWAY.

service by one of the leading electric companies. It will strike the reader at once as being very close in general outline to the Field locomotive operated on the New York elevated road in 1883. The principal difference, however, consists in the application of the power and in controlling the current. The armatures of the motors are mounted upon hollow sleeves concentric with the axles. The current is governed by what is called a series parallel controller, which controls the current in starting, effecting a large saving in the amount of power consumed.

The latest claimant for honors is the Heilman electric locomotive, illustrated in Figures 27 and 28. This locomotive has been built from the designs of M. Heilman, in France, and consists of a complete electric-power station on wheels. There is a boiler water-tank electric-generator driven by a compound engine, and a dynamo of 20 horse-power driven by a separate engine for exciting the fields of the large machine. Eight motors attached directly to the axles of the car utilize the current from the generator. The operation is as follows: Steam is generated in the boiler and conveyed to the engine which drives the large generator, the fields of which are excited from the small dynamo. The current from the large generator is delivered to the motors which propel the train. The losses in this machine as a whole are necessarily great, owing to the many conversions, and while it is interesting from a scientific and engineering standpoint, it is safe to predict that it will soon be relegated to a similar place in history as the one now occupied by the famous Fontaine steam locomotive, which, it will be remembered, was built about ten years ago, created a sensation by the extraordinary claims of its inventor, and two years later was sold for scrap at about one-tenth of its original cost.

Figure 29 shows one of a number of locomotives now under construction, to be used in hauling freight and passenger trains through the tunnel of the Baltimore and Ohio railroad at Baltimore. They are designed to haul a maximum load of 1200 tons at speed of fifteen miles per hour, or, in passenger service, 500 tons at thirty miles per hour. They will weigh 100 tons and have a capacity of 1200 horse-power each. The record of these locomotives will be watched with interest, but as they are to be driven from a central power-station in the same manner that the present surface electric railways are operated, there is little doubt that they will prove as successful as their smaller, though equally important predecessors.

The latest and most important applications of electricity to electric traction are the Liverpool overhead railway and the Intramural railway at the World's Fair. Figure 30 shows one of the cars of the former system.

In 1890 representatives of the Metropolitan railway, of London, presented to a parliamentary committee an estimate based upon the results obtained from the Daft experiments on the New York line, of the cost of equipping and operating a large electric railway system, in which they concluded that it would cost 75 cents per train-mile for motive-power alone, exclusive of interest on the investment. In contradistinction to this it is a pleasure for the advocates of electric traction to know that the Liverpool road is now operating six miles of railway with trains weighing thirty-five tons, at an average speed of twelve miles per hour, for eight cents per train-mile, which, after allowing for the difference in weights of trains, is less than one-sixth or a little over of the above amount.

The trains of the Intramural road ran upon a standard 4′ 8½″-gage track supported by a graceful elevated structure. The road was equipped with fifteen trains, twelve of which were in continuous operation, each one being driven by four 125-horse-power motors attached to the axles of the forward car. These trains carried about 6,000,000 people during the Fair, at a cost for motive power of one-quarter of a cent less per passenger, and a saving of over 50 per cent. in fuel, compared to its latest-equipped steam rival operating under equally favorable conditions.

Since the practical demonstration of electric traction at the exposition in 1883, the electrical worker has succeeded in providing almost every city in the United States, having a population of over 15,000 people, with rapid transit, and to-day, conscious of work well done, looks toward the elevated railway as his legitimate field for future triumphs.* We shall probably see the electric locomotive gradually displace the steam-engine in the elevated-railway service, and at no distant day its adoption on the suburban service of our steam-railways. On trunk-lines operating many trains it is now practicable to build power-stations at equidistant places, transmit the current at a high voltage to substations in which will be located either motor-transformers or batteries to convert the energy and deliver it to the working conductor at a safe pressure.

The line of improvement that is most desired in direct-current motors is some means of making them more economical in consumption of current when starting. If this objection can be removed work in the power-station would be much lessened and economy thereby increased.

While the alternating and multiphase systems offer many advantages for the transmission of electrical energy, they have not yet proved themselves applicable or able to grapple with the electrical-railway problem, in which many small motors are required to start intermittently with great torque or rotative effect.

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*Since this article was written two large elevated railway companies in Chicago—the Metropolitan and Northwestern—have decided to adopt electricity for motive power. B. J. A.

The London *Morning Advertiser* of December 7, 1842, in commenting upon Davidson's locomotive, previously described, said: "Such being the progress of experiments, it is not being too sanguine to expect that some lucky genius will at no very remote period ascertain a means of adapting this extraordinary and easily-developed power to supersede steam on railways, at the printing-press, in vessels, at mills," etc.

The truthfulness of the prophecy is shown in the fact that electricity has almost completely superseded steam in operating small printing-presses, has displaced animal power on almost all the surface street-railways, and is rapidly encroaching upon the field of the steam-locomotive. It has not yet supplanted its rival in the operation of large vessels, although its application to small electric boats and launches is rapidly becoming general, and it is safe to predict that before many years shall have passed it will fill its place in this important field, making good the prophecy of the London editor who long since passed from the field of material triumphs.

NOTE—The illustrations accompanying this paper, numbered Figures 4, 9, 10, 13, 14, 16, 19, and 25, have been reproduced from Messrs. Martin and Wetzler's work on the electric motor and its applications, by the courtesy of the W. J. Johnston Co., Limited, of New York. Figure 1 is reproduced from the *Electrical Engineer* and Figure 30 from the *Western Electrician*.—THE EDITOR.

THE EARLY STEAMBOATS ON THE LAKES.

By J. F. Holloway,

Past-President American Society of Mechanical Engineers.

THE writer readily recalls the time when, as a boy seated on a farmer's wagon and coming over the crest of a hill, he for the first time saw stretched out before him the blue waters of Lake Erie. He does not now and can never again hope to recall the mingled feelings of surprise, wonder, and awe that this first sight brought to him ; neither can he explain to himself why it was that the broad expanse of water that lay spread out before him seemed to rise upward on a gradual inclined plane, until, at the extreme verge of the horizon, the blueness of its waves melted into a cloudless sky of like tint. To the boy who had only seen the little mill-pond of the village in which he was born, there was something unspeakably majestic in the vision of the waters before him, which seemingly had no farther boundary than the overhanging sky, and wherein the distant white-winged vessels seemed to float alike in air and in water. Remembering in after years the impressions made on him by this first sight of this inland sea, he could readily understand something of the irresistible fascinations which tempted the boys of forty or more years ago to leave comfortable homes to sail the seas over, to fathom their mysteries, and reach their farthest shores.

Later on, opportunities came for more frequent visits to the near-by and thriving lake port, and for a closer acquaintance with those who were wont to go down upon the sea in ships, and for a somewhat clearer knowledge of the then newer methods of transportation on water with the aid of steam. While the growing lake town had in it many new and strange things to interest and charm a country boy, it was at the riverside and along the docks that he found most to occupy his attention, and most that puzzled him to understand. As there were at that time no railroads in that part of the country, the bulk of the travel westward was by water and through the connecting lakes, and, although vessels propelled by sails had not entirely ceased to convey those migrating from the east in search of new homes on the then boundless prairies of the west, it was the side-wheel steamers that were now doing the most of the business. While these boats were numerous, they were mostly small ones which, if placed beside the great steamships that float in and out of the deepened harbors of to-day, would seem quite insignificant, but, as compared with the little schooners and brigs they were displacing, they were immense.

In the early days of steamboat-building there was much experimenting as to what was the best kind of machinery to be employed; indeed, so distinctly different were the types of engines used that persons familiar with the different steamers could readily distinguish them when, to an unpracticed eye, they were but dots upon the horizon, and so varied was the drumming of their revolving wheels, and the extent or sharpness of their escaping exhaust steam, that in the darkness of the night or when hidden under a heavy fog they could be named. Some of the boats were propelled through the medium of a walking-beam which projected above the cabin, and to which sometimes there was attached the figure of a galloping steed whose alternate rising and plunging forward was perhaps intended to indicate, not only the taste of the owner or builder and the speed of the boat, but, to some extent, the horse-power of the mechanism to which it was attached. Other boats had what were known as "square engines," which also projected in part above the cabin, but which had in place of the tumbling beam a vertically-moving cross-head, with swinging connecting-rods on each side, attached to the cranks on the paddle-wheel shaft, and which, when in motion, were not unlike a pair of crutches under a lame man, and seemingly for the same purpose of getting ahead. Others were driven by what were known as horizontal engines, which, while they took up a considerable space on the main deck, left the cabin above them a long and uninterrupted saloon which, while adding to the comfort of passengers, gave greater opportunity to the decorative artists of the time in which to show their ingenuity and skill. Many an old-time traveler can doubtless recall the bits of scenic painting displayed on the panels of the long row of stateroom doors, on either side of the cabin, the subjects of which ranged from the ducal palace of a prince on the banks of the Rhine to the rustic ruin of a hunter's camp in the wild west.

The captains of these early and, as their gorgeously-illustrated placards announced, "magnificent steamers," were quite a distinct class of citizens. They were mostly recruited from the ranks of the successful masters of sailing-vessels, and many originally were no doubt either sailors from salt-water or persons who had been trained under sea-captains and who had imbibed their somewhat martinet-like manners. The difference between the captain of a lake steamer and the captain of an Ohio-river steamboat was marked to a degree readily noticeable by any observing traveler. The lake captain, as he walked his deck, was a man not readily approached, and the anxious passenger impatient to reach the end of his journey rarely ventured to question him as to how much longer he was going to lay in port or when he expected to arrive at the end of the route, preferring to bide his time and procure the desired information from the more approachable first or second mate. Not so with the captain of the Ohio-river boat. Nearly every one along his route knew him by sight or name, and many a signal for him, or possibly for his pilot, was waved from behind half-opened farm-house doors along both banks of the river. When, after the jangling of many bells, the hoarse roar of the exhaust-pipes was silenced and the bow of his boat was pushed well on the bank, he was among the first to go on shore to shake hands with the principal citizens of the town, who at such times usually lined themselves up awaiting his arrival, and to inquire how crops were looking generally, and if the late cold spell had damaged the early corn. As the business for his boat was mainly picked up along the shore, it was to his interest to know what the prospects were, and as well his desire to stand well in the esteem of all.

One of the peculiarities pertaining to the early steamboats on the lakes was the use of the space each paddle-box afforded as a place to be dedicated to paintings of historic events, and the earliest examples of mythological teaching that came to the country boy were the pictures they sometimes exhibited, in which trident-bearing gods of the sea were tangled up in the waves with a breed of horses to him before unknown. On others, the stalwart figure of some well-known Indian chief clad in fringed buckskin and adorned with feathers, sad, yet defiant, looked out over the waters he once called his own. When the name of the boat was a short one, or the name of the line to which it belonged would permit, the letters of which it was composed or the initials of the line were shown there, wrestling with each other in a monogram in which each letter was seemingly striving to get an underhold, and which, taken as a whole, formed a puzzle never to be found out until by chance one heard its mysteries unfolded by some passenger who, standing on the deck near it, with his cane traced out each curve and pronounced its name.

While the travel westward in these times was sufficient to fill all the steamers to their full capacity, there still existed considerable rivalry between them. Each claimed a superiority in speed and accommodations and in the special strength and safety of its boilers, for in those days the use of steam was so recent that many who ventured to travel on vessels thus propelled felt that they were taking great risks. The stories told by the agents of the different boats as they solicited travelers, as to the extraordinary strength of their boilers and the low pressure of steam carried, would sound oddly enough now, when boilers on boats carry steam of 250 pounds pressure, as compared with the 30 or 40 pounds years ago. The theory of the steam-engine and the apparent complications connected with its use were to many of the passengers so hopeless a problem that they gave up its solution at the very start, while others, more persistent, spent many of their leisure hours between ports in seeking to solve its mysteries. Among the later was a well-dressed, thoughtful-looking man who at one time was a passenger on a somewhat famous boat in its day, in which the propelling power consisted of a row of return-flue boilers down in the hold, and a single horizontal steam-engine in plain view on the main deck, directly connected to the cranks on each paddle-wheel shaft. With so much in plain sight, it would seem that little or no explanation would be required by any observer, but with a belief no doubt that there were other necessary and hidden mechanisms, this would-be scientist spent many hours of several days in watching the operation of the machinery and in tracing out the sequence of its motion.

Standing near the steam-cylinder, he would watch with interest the alternating movement of the piston-rod with its attached cross-head, and the long iron-strapped wooden connecting-rod reaching forward to the paddle-wheel shaft, noting with care how its swinging end seemingly turned the cranks to which it was attached. He would then turn back to the steam-cylinder, apparently to trace out some unseen or overlooked appliance believed to be essential for the work to be done. Finally, after several days of silent contemplation and with an unsatisfied expression on his face, he ventured to approach the person in charge and the following conversation was had :

"I beg pardon, sir, but I believe you are the engineer of this boat," said the passenger, to which the somewhat grimy man with an oil-can in his hands briefly replied, "I am."

"Well sir," said the well-dressed stranger, "I am very much interested in mechanics, and have given the study of the steam-engine much thought, and am quite familiar with the generation of steam and its application to machinery generally, but there are some things connected with the application of steam to the propelling of boats that I cannot quite understand, and I will be greatly obliged to you if you will kindly give me the required information."

"All right," said the engineer, as he reached forward to dope a suspiciously dry looking spot on the main slides ; "fire away. What is it?"

"Well," said the stranger, timidly, "there are your boilers," pointing to the two smoke-pipes which on either side of the boat passed up between decks ; "I understand all about them, and here is your cylinder, and that is all clear to me, but what I cannot quite make out is where does the steam strike the paddle-wheels?"

This was a stunner for the knight of the starting-bar, who no doubt had never passed a civil-service examination, but, after scratching his head with his unemployed hand, he replied: "Well, the fact is, stranger, I have only been on this boat but a short time, and I'm —— if I know."

Equally crude were the ideas entertained by many persons as to the power developed by steam-engines and boilers, and as to the methods by which their power was ascertained. As the early-built steam-engines were mostly used to take the place of horses in driving machinery, it was usual to rate them by the number of horses they displaced, and thus the term "horse-power" became not only convenient, but common. At the time referred to no steam-indicators had been invented or used, or, if they had been, they had not then penetrated the backwoods of the west.

The bright young student fresh from some technical school, with his little black walnut box filled with shining wheels and springs, who now goes about the country and at such short notice will take a diagram from your engines, and, with a few adjustments of his pocket slide-rule, tell you not only what the horse-power of your engine is, but what it ought and will be if you will permit him to adjust its parts, was then an unknown product, and no doubt had he then appeared, in advance of his time, he would have received but scant courtesy from the old-time engineers who received book-learning only at a heavy discount.

Illustrating a simpler and equally graphic method of computing the horse-power of a steam-engine and boilers, was an incident that came to the knowledge of the writer at a time when, as he then thought, there was nothing left for him to learn about steam-engines and boilers, or their attachments.

The steam-boiler of the era to which reference is made was a crudely-constructed affair, and the boiler-shops in which they were built, when not under a tree, were housed at best by a rickety shed. Beyond a simple hand-lever punch with which to perforate the holes in the plates to receive the rivets, it had few tools other than a hand-hammer and a sledge, and of course the inevitable drift-pin. As the rivets were then headed cold, the principal tool used was the sledge, although a few artistic boiler-makers did employ a button-set, to take out some of the worst dents left by the hand-hammer. That boilers thus built would require the aid of some extraneous substance in order to enable them to hold water will be readily conceded by those who are familiar with their use.

There had been built at the lake port previously referred to a steamer which, in size, power, and model, was expected, as the builder said, "to take the broom." Of course the boilers and engine had received especial care in their design and construction, and were expected by their extra power to supplement any errors in the model or hull that might be developed. The boilers had been placed in the hold of the boat, the engine lined up and connected, and the eventful trial of both was near at hand The day had passed and gone, and the shades of evening were fast falling along the river and on the now nearly-deserted boat, when a two-horse wagon loaded with the by-product of a livery-stable drove into an alley leading to the dock to which the boat was secured.

With discreet celerity a transfer of the content of the wagon was made to the hold of the steamer, where it was evenly distributed within the boilers; after this was done, the boilers were closed up and pronounced completed and ready for use.

During this time an observant stranger, doubtless also a seeker after knowledge, had been lounging about the dock intently watching the proceedings, but with a much-puzzled air. After it was over, and as he stood by himself fumbling his frouzy whiskers, he was heard to say: "Gosh! I've heerd a good deal said about the hoss-power of bilers, but I never knew before how they got at it, but I see it now; they reckon it by the quantity of hoss-manure they put in 'em."

As the years passed by, the approaching railroads from the east and from the west narrowed down the intervening water-route until from Buffalo, at one end of Lake Erie, to Monroe, Michigan, at the other, was all the space left to be covered by steamboats, and for this the railroad companies built and equipped a line of large and fast side-wheel boats, which in point of speed and elegance equalled anything then afloat on the Sound or the Hudson river. Here and there you may yet come across a quiet, gray-haired man who, as captain or engineer, sailed on these now well-nigh forgotten floating palaces, and if you evince an interest in them, and especially if you have any knowledge as to their performance, his eye will light up and his face brighten with pleasure, and if he be in the proper mood he will rehearse tales of gone-by experiences that not only will interest and delight you, but will convince you that, if wisdom did or did not all die out with the men of the past, it certainly did not all come in with the men of the present.

While the change from the railway-cars to the steamboats was a pleasant one during the warm months of summer, it was not always so in the spring and in the fall, and of course in the winter their place was filled by the stage-coach along the southern shore of the lake, but soon through the forest and among the newly-cleared farms, the new-laid iron rail made a connecting highway over which the iron horse speedily moving onward sent back a defiant challenge to the slower moving steamboat which was soon to be relegated to the past, as had been the sailing craft and the birch canoe of the Indian that had preceded them. The side-wheel boats of which this is a brief account have long since passed away. Their hulls stripped of cabins and machinery, they for a time served to transport lumber, etc., but time with its remorseless tooth has long since eaten out their symmetry and strength, and in out-of-the way places they lie moldering on the banks, or are sunken beneath the waves above which they once so proudly floated.

In great cities of the west are living yet first settlers who readily recall trips made on these early steamboats, and matronly grandmothers will tell to listening children stories of the gaiety and fashion displayed within their brilliantly-lighted saloons, when, after supper, the well trained-waiters formed a band whose music filled all the space with scenes of mirth and revelry, unknown to travelers of the present.

In the village graveyards that line the shores of these inland seas lie many of the men to whom was entrusted the comfort and safety of the great number of persons who in those early days sought in the then far west a home for themselves and their children. As one who knew something of the lives of these men, and of the hardships and perils to which they were exposed, and of the responsibilities that rested upon them as captains, engineers, and officers of the early steamboats on the lakes, the writer desires to testify to their many good qualities, and to say that as a class they were rarely excelled in the conscientious performance of their duties. Often unlearned as to the courtesies of life or in the refinements of social usages, they had in them the stuff of which heroes are made, and when occasion required, as it often did, they displayed an unselfish heroism which, more widely known, would have brought to them the recognition and fame they well deserved but rarely received.

ELECTRICITY

Conducted by Franklin L. Pope.

WITHIN the last two or three years there has been a marked tendency towards the use of the largest possible dynamo units in arc lighting, as well as in incandescent lighting and railway work. But the peculiar difficulties to be surmounted in the case of an arc machine of great capacity are much more perplexing than those which are due to mere size. In the low-tension machines, the difficulties are principally those of mechanical design and proportion, but in the case of the arc machine, the working potential increases at the rate of 50 volts for each additional lamp, and thus the pressure soon reaches a limit beyond which, under ordinary conditions, it becomes wholly unmanageable. Tests have recently been made of a new arc machine of the Excelsior type, which has successfully withstood the enormous potential of 10,000 volts at full load, with a current of 10 amperes and a speed of 625 revolutions per minute. The machine will supply 200 lamps of 2000 nominal candle-power each, and weighs, complete, 16,000 pounds. One of the peculiarities of the design is that the armature-shaft is carried in a single central bearing. The success of these huge machines appears likely to create something of a revolution in the practice of large central stations, as it seems to be the universal opinion of central-station men that the largest practicable units are by far the most economical, not only in first cost of machinery and of line per lamp operated, but in proportionate cost of attendance and repairs as well. It is not many years since a central-station man would have been aghast at a proposition to carry a potential of 10,000 volts upon an arc-lighting circuit, but in this respect, as in many others, the electrical world is making rapid progress.

AT a recent meeting of the New York Electrical Society W. S. Hadaway, Jr., read a carefully prepared and exceedingly instructive paper on the engineering aspects of electrical heating. The application of electricity to the heating of street-railway cars has frequently been referred to in this Department, and there has been more or less discussion as to whether or not it is profitable for a railway company to heat its cars in this way, some having contended that it would be much more profitable to sell its electric power at 2 cents per kilowatt and heat its cars in the old way means of coal-stoves. Of course the cost of electricity per horse-power per month, as delivered to the car, is a somewhat varying quantity under different conditions, but in some instances it has been figured out as low as $2. Mr. Hadaway says that experience during the past winter has shown that a surface of 27.5 square feet of black or dull bronze radiating surface is sufficient, when raised to a temperature of 135° F. above the surrounding air, to adequately warm a well-built 20-foot car, and this temperature may be continuously maintained with an expenditure of electrical energy of 100 watts per square foot. On the basis of $2 per horse-power per month, therefore, the cost of operation would figure out about 27 cents per day for each car. But in practice it is not found necessary to run the whole radiating apparatus for a considerable portion of the time, and therefore the average cost is reduced to about 20 cents per day. It is conceded that a coal-stove costs about 15 cents per day to maintain in operation, besides which it occupies the room of one paying passenger. The electric heat is far more uniformly distributed than that of the stove can possibly be, and is incomparably more healthful and agreeable in every way.

REFERRING to the practical aspects of

electrical cooking, Mr. Hadaway states that, under existing conditions, electrical heat can be delivered from central stations at an efficiency of 7 per. cent. as against 4 per cent. from coal burned direct in a kitchen range, from which he concludes that, if the problem of boiling water were eliminated, electricity would be considerably more economical for cooking than either coal or gas. But even conceding the cooking by electricity to be considerably more expensive than by direct combustion, the advantages attendant upon its adoption appear to be sufficient to compensate for a wide disparity in price. A prominent hotel-man has stated that if the cost of electricity for cooking were even four times as great as that of coal, it would be found advantageous to use it on account of its cleanliness, great facility of regulation, and uniform temperature, to say nothing of the cooler kitchens and better general work. A hotel installation now in successful operation in New York city is described as comprising an oven of two compartments, a broiler of three sections, portable stoves of various sizes, tea-kettle and farina-boiler having independent heaters directly attached, and a plate-warmer. Culinary operations are carried on beneath a hood ventilated by a fan driven by a small motor, and the kitchen is found to be very comfortable as a dining-room. At 5 cents per horse-power-hour, which is a rate quite within the limits of commercial possibility for day-time service, the cost of electricity per person per day would be only about 2 cents. It ought to be possible, in most cases, to furnish current from a water-power station, where one is available, as low as 2½ cents per horse-power-hour in the daytime, which would bring the cost per person per day down to about 1 cent.

A TROLLEY system, arranged upon the well-known three-wire system used in many of the electric stations installed by the Edison companies, is described by A. C. Balch in a recent number of the *Street Railway Review*. The wiring of the car, the overhead construction, the track, and in fact the entire installation outside the power-house is in accordance with ordinary usage. Each feeder, or set of feeders, supplies a separate section of the trolley-wire, which is insulated from the adjacent section in each direction. The track fulfils the electrical conditions and functions of the neutral wire in the three-wire system. Each alternate section of the trolley-wire is of opposite polarity, there being a difference of potential of 1100 volts between each two adjacent sections. The station installation corresponds, in its details, with the usual practice in three-wire lighting stations, except that it is of course not necessary to use potential-regulating devices on the feeders. The operation of the dynamos is precisely the same as in ordinary railway installations. Among the advantages of this arrangement, as enumerated by Mr. Balch, are a saving of 50 to 60 per cent. in copper in the original installation; a complete metallic circuit, and, thus far, an apparently complete exemption from any electrolytic action upon the gas- and water-pipes. Two years experience under the ordinary conditions of electric-railway work have apparently failed to develop any inherent disadvantages in the system. With some modifications, it would seem as if this plan might be admirably adapted to suburban electric lines of greater than ordinary length.

SOME very successful trials of considerable duration have been made of an apparatus for electrically lighting a private car by power taken directly from one of the axles of the truck, supplemented by a storage battery of moderate capacity. The dynamo is mounted on the truck in almost exactly the same manner that the motor is mounted on a trolley-car, being sleeved to the axle at one end, and attached by a stirrup support to the truck-frame at the other. The mechanical connection between the armature and axle is made by spur-gearing, in which particular it also resembles the mechanism of a trolley-car. The dynamo is compound-wound, with the direct and shunt windings in opposite directions. The resulting differential field is nearly constant for all speeds; it acts, in fact, as an automatic governor and keeps the electromotive force nearly constant. It is said that experience has demonstrated that the output of the machine varies less than 5 per cent. between speeds of twenty-five and sixty miles per hour. An automatic cut-out and pole-changer are provided, the office of which is to disconnect the storage-battery from the dynamo when the speed falls below twenty miles per hour, or the train stops, and to take care of the polarity when the car (and consequently the dynamo) is run backwards. The storage-battery is designed to have sufficient capacity to maintain the lights for six hours without the assistance of the dynamo. The total weight of the electrical equipment, including dynamo and batteries, is about 1000 pounds, and the cost of fitting up a car is said to be in the neighborhood of $650. If this plan is well worked out in its details, as it certainly appears to be in this instance, there would seem to be no reason why it should not furnish an ideal method of lighting railway-cars. The general conception is of course old, but some of the details of the present arrangement display no small amount of ingenuity and adaptation.

In a paper recently contributed to the *Electrical Engineer*, Messrs. Edwin J. Houston and A. E. Kennelly have discussed the practical aspects of the problem of long-distance transmission of electric energy from the plant at Niagara Falls. Some of the assumptions made by these gentlemen are undergoing severe criticism from electrical engineers, but the conclusion deduced is, that the possible limit of distance to which an aggregate of 50,000 kilowatts or more of energy can, in the present state of the art, be profitably transmitted, is something like two hundred miles. Everything depends, of course, upon the maximum voltage which it is found to be practicable to employ, and this has been assumed by the authors at 50,000 volts. It is very doubtful if anything like this pressure has ever as yet been actually used, though it is asserted that 30,000 volts were successfully applied in a portion of the Frankfort-Lauffen experiments. The paper is a very suggestive one, and has given rise to an interesting and instructive exchange of views among progressive electrical engineers.

Mr. Charles E. Emery points out that the very low price assumed per horse-power capacity of motors, generators, and transformers, is one of the principal elements which make electrical transmission through such a long distance appear commercially practicable. His own estimate is that the total cost of the translating machinery at the receiving station will be more nearly $35 per horse-power than $15, the figure adopted by Houston and Kennelly. Upon this basis, Mr. Emery finds that Buffalo will be within and Syracuse without the circle of economical transmission for a 10-hour day, but that for a 20-hour day, both cities will be included within it. Manufactories requiring power for twenty-four hours per day can however most profitably be located directly at the Falls. Professor W. A. Anthony contends that, upon the assumptions of cost of lines and apparatus adopted by Houston and Kennelly, power cannot be delivered at Albany, even with an initial pressure of 50,000 volts, at a price competitive with steam, unless the machinery is operated continuously at its full capacity. The figures of cost are also questioned by Messrs. F. B. Crocker and C. F. Rittenhouse, who express the opinion that the cause of long-distance power-transmission will not be helped by assuming the lowest possible costs and the highest possible efficiencies. Estimates on new and untried schemes should be allowed the most liberal margin possible. Mr. J. B. Cahoon, an engineer of large experience in power plants, makes the general criticism that a factor of safety of at least two ought to be introduced into the calculations of Messrs. Houston and Kennelly. Mr. H. Ward Leonard observes that all the figures are based on an assumed sale of 119,000 horse-power, and that, in order to produce this maximum load, some 300,000 horse-power must be sold, as represented by the aggregate rating of motor capacity, and remarks, very pertinently, we think, that this amount of power is not likely to be disposed of this year or next.

He further expresses the opinion that a power-plant using triple-expansion engines and located on the water-front in Buffalo, will be able to compete commercially with power tranmitted from Niagara. Messrs. Houston and Kennelly have replied to a number of these criticisms, and, at the time of writing, are maintaining their original position with a good deal of spirit. Most of these comments and criticisms have appeared in the columns of the *Electrical Engineer*, and taken together, they certainly form a most valuable addition to the body of existing literature relating to long-distance power-transmission.

AN electrical engineer in Chicago has been for some time engaged in the perfection of a road vehicle to be propelled by electricity, and, according to the published accounts in the technical journals, his efforts have been crowned with a considerable degree of success. The vehicle is a two-seated surrey wagon, built with reference to strength more than to unusual lightness. A motor of 2 horse-power is carried in a steel frame between the front and rear axles, and is coupled to the rear or driving axle by a geared intermediate shaft and sprocket-chain. Twelve cells of storage-battery furnish the motive power, six being placed under each seat, and are designed to furnish sufficient current for a run of 60 miles under average conditions. The total weight of the entire outfit is given as 1270 pounds. The average consumption of energy on level city streets, taking the condition of the pavements as they are found, is said to be less than 2 horse-power at a speed of ten miles per hour. At the schedule rates at which electricity is supplied in Chicago, it would appear from this statement that the cost of current sufficient to make a daily trip of fifty miles would not exceed $10 per month, which, as most of us who have tried it are well aware, is rather less than it costs to furnish provender for a horse. In fact, what with electrical vehicles and the superior telford roads which we are certain to have within a few years, it begins to look as if that noble animal would soon become an article of mere luxury rather than of necessity. It certainly appears as if the Chicago engineer had brought the matter of road transportation by electricity very nearly to a commercial basis.

DR. TALMAGE'S Brooklyn Tabernacle having been destroyed by fire for the third time, the usual attempt has been made to attribute the disaster to electricity. Upon the occasion of the last preceding fire, it was claimed that the wires had been "struck by lightning" and had set the switchboard on fire and so the church, but, unfortunately for the propounders of this theory, the switchboard was ultimately recovered from the ruins, having escaped the general destruction, and proved to be intact, bearing not the slightest traces of any such casualty as had been alleged. The investigation which followed the last fire proved, in an equally conclusive manner, that electricity had nothing whatever to do with its origin. This however will make no difference; it will doubtless always be said that the Tabernacle was burned by electricity, and we shall be much surprised if it does not hereafter figure in the tabular annual statements of losses chargeable to that agency! Electricity, or, more properly, defective wiring, has fires enough to answer for, without being wrongfully charged with those of which it is innocent. The National Board of Underwriters has taken the ground, and not a moment too soon, that all wires out of sight should not only be thoroughly insulated, but should be placed in tubes, so as to be always accessible as well as protected.

THE village of Jamaica, N. Y., is lighted by a system of small electric arcs, which presents a number of features of technical interest. The current used is only 4 amperes, as against 10 amperes for the ordinary full-arc and 7 for the so-called half-arc. Two dynamos are in use, each carrying 70 lamps at a terminal potential of about 4000 volts. Each lamp is fitted with a single pair of plain half-inch carbons, which will burn from 15 to 16 hours —long enough for an all-night run. This system appears to be particularly well adapted to the use of towns in which the streets are heavily shaded, a condition of affairs which renders the use of the larger arc lamps uneconomical. In the operation of the Jamaica plant, it is found that three of these small lamps require a trifle under one horse-power, which in view of the excellent distribution of the light would seem to make it an exceedingly economical and effective arrangement.

It has always seemed to us that the schedule of rates for telephone service in our large cities has heretofore been arranged upon an eminently inequitable basis, in that one making use of this convenience only a few times per week has been compelled to pay exactly the same amount as another party who makes use of it perhaps a hundred times as much, so that the annual charge per subscriber, while certainly not excessive when computed upon the basis of the total number of communications passed through the exchange, has been practically prohibitory to a great number of persons who would gladly provide themselves with the service if the payment could be in some sort of proportion to the use made of it. The Metropolitan Telephone and Telegraph Company of New York announced a new schedule on June 1, in accordance with which future applicants for telephone service may have the option of paying somewhat in proportion to the service required. The minimum annual rate will hereafter be $100 for a station on a two-party line, or $150 for an individual line. The former price will entitle the subscriber to 700, and the latter to 1000 connections per annum. The rate for additional connections will be $12 or less per hundred, according to the amount of extra service. An additional reduction will be made on extra business when contracted for in advance. A charge of $15 will also be made for installing a station. The character of service under the revised rates will be in all respects the same as under the arrangements heretofore existing. This step has doubtless been encouraged by the extensive use which has been made by transient customers of the one thousand or more "pay-stations" which have been established throughout the city during the past two or three years, and which have proved to be a very great popular convenience.

In one of its recent issues, the *Electrical Engineer* publishes in parallel columns two illustrations, reproduced from photographs, showing typical examples of electric-power line construction in Europe and America, which furnish an instructive opportunity for comparison to those who are wise enough to appreciate it. One is the eighteen-mile line from Tivoli to Rome, Italy, which is constructed with steel poles, each formed of two T-bars 21 centimeters wide and firmly bolted together. These are placed 30 meters apart—a little less than 100 feet—and carry four twelve-strand copper cables, each 2.6 millimeters in diameter, besides two silicon-bronze service wires 2 millimeters in diameter. Oil insulators of white porcelain mounted on steel brackets serve to support the wires. The other line is an example perhaps somewhat above the average of the usual style of construction adopted in this country, consisting of heavy wooden poles with pine cross-arms strengthened by light diagonal iron bracing, in the manner employed in the telephone lines, and fitted with green-glass insulators set upon wooden pins. Of course it is cheaper, both in the short run and in the long run, to use the wooden poles and arms, as the interest on the more costly steel construction would doubtless amount to more than enough to replace the wooden construction every twelve or fifteen years, but we cannot see why the same argument should not be equally applicable for example to the flumes and penstocks of the hydraulic machinery. Only the other day we had occasion to examine a recently completed electric-power plant, in which the dam, head-race, tail-race, and foundations were all of massive masonry of most admirable construction; the penstocks and conduits and wheel-cases were of iron, and the construction and fittings of the power-house were in every respect strictly first-class, while the line on the other hand was carried on cheap and slender wooden poles, not strong enough even for a good telegraph line, with ordinary sawed cross-arms and wooden pins, and glass insulators to match. The incongruity was really painful. No doubt the electric fluid will run as freely, at least for a time, over this line as over a better one, but still it does seem extraordinary that the same permanent and excellent style of construction employed in the power-house should not have also been maintained in the one part of the work which is principally visible to the public, and which at most would not constitute 5 per cent. of the whole cost.

WE have never seen in this country a single example of strictly first-class overhead line construction. That of the electric railways in some instances comes very near it, and some of the recent construction of the telephone companies is but little amenable to criticism, in view of the purpose it is intended to subserve ; but as to the electric-light and -power lines, almost none of them, so far as our observation has extended, are more than fairly good, while a majority of them are about as bad as they well can be. One would think that the line was a factor of sufficient importance in a system of electrical distribution to be worthy of more attention than has hitherto been bestowed upon it, but for, some reason or other, it seems to have been tacitly admitted that any common laborer knows enough to set poles in the ground and hang wires on them, and that any kind of cheap stuff furnished by the dealers in supplies in the way of fixtures and fittings will do well enough.

THE subdivision and distribution of artificial sources of illumination, although a problem which has become of the highest practical importance, appears to have failed to have received the amount of consideration to which it is entitled. We are very glad to note that it has been taken up by so competent an authority as Professor W. A. Anthony, who, in a paper read before the annual meeting of the Institute of Electrical Engineers, has laid down some of the leading principles necessary to be kept in mind in designing a system of illumination which shall give the best distribution of light at the least cost. In this paper he shows that the usual method of dividing the area to be lighted into imaginary squares, and estimating from a source of light in the center of each square, falls very short of fulfilling the conditions required. In a rectangular area treated in this manner, the corners of a large space may receive less than one-third the intensity of illumination that the central portion does. Comparing arc and incandescent lamps as sources of light, upon the basis that the minimum illumination shall be the same in each case, Professor Anthony finds that the efficiency of the arc lamp has been in popular estimation, greatly overrated and he reaches the conclusion that unless the area to be lighted is so large as to require 500 incandescent lamps uniformly distributed, the use of full arc lamps consuming an equal amount of energy will leave some parts of the area less fully illuminated. The use of arc lamps for street-lighting, located at intervals of 1000 to 1600 feet, as they are often seen in pretentious villages and suburban towns, he regards as a great waste of money, inasmuch as the same power employed to operate incandescent lamps at intervals of 100 to 200 feet, would give a better illumination for practical purposes.

THE usual annual bill for the establishment of a government telegraph has been introduced into congress. The present project is opposed by Postmaster-General Bissell, on the indisputably correct ground that it would be certain to add enormously to the annual deficit of the department without correspondingly advancing the interests of the public. It has always been a mystery to us, and one which we have been wholly unable to solve, why the workingmen's organizations should feel called upon to declare in favor of a government telegraph. Why should the workingmen, who so seldom use the telegraph, tax themselves for the purpose of furnishing telegraphic service at less than cost for the benefit of the wealthy business firms and corporations from whom the telegraph companies now derive at least 90 per cent. of their total revenue ?

ARCHITECTURE

Conducted by Barr Ferree.

THERE are many kinds of architects. There is the successful architect, the unsuccessful architect, the satisfied architect, the soured architect, the good architect, the bad architect, the artistic architect, the sensitive architect, the engineer-architect, the trumpet-blowing architect, the carpenter-architect, the professorial architect, and the École architect. No especial significance is intended in the order in which these names are set down. The variety is large and interesting, and, if architects were marketable commodities, it would be possible for a purchaser to have choice of a great diversity of brands. The differences are not always great. Some of these classes run very close together. The unsuccessful architect and the soured architect, for example, are usually found united in one person in a union more complete than that which joined the twins of Siamese memory. The successful architect is often the same as the satisfied architect, though it is easy to conceive a difference. The diversity of architects is, in fact, quite as great as diversity in styles. We have good and bad architects just as we have good and bad styles and good and bad buildings in them. But the degrees of good and bad are not continuous through the three series. Good architects often produce very bad buildings, and good buildings will sometimes be done by bad architects. It is true that neither of these cases is usual, but certainly some astounding examples of the former might be named. The carpenter-architect is now an almost extinct species. He is to be found chiefly in the smaller cities and towns, where his light, while not always hid under a bushel, is still tolerably well eclipsed. Few new specimens of this species are grown nowadays, and collectors of architects would do well to capture such as may not be already placed in museums. There is sure to be a rise in their value the moment they become wholly extinct. Still, the carpenter-architect performed yeoman service in his day, and, though we may despise him now or look upon him with friendly curiosity, he should not be viewed with too great contempt. We do not need him now—his day is past. In his stead has come a motley group representing all phases Some of these have been named at the beginning of this paragraph.

THE successful architect is a proud creature. It does not matter whether his success has come through desirable and influential relations or through his own exertions. The former is more likely to be the case, and every ambitious architect who would be successful would do well to maintain a social department in his business. The social element is to the architect very much what full page advertisements are to the dealer in dry-goods. It is even more important than a well-equipped drafting-room. The successful architect is usually fully alive to his success and the fullness thereof. We have met specimens of the class who were looking forward to further heights to climb, additional triumphs to achieve. These are admirable feelings and much to be encouraged. On the other hand, no one can blame a successful architect, any more than a successful politician, for feeling satisfied with himself and what he has done. And of course it does not matter how it was done if it was done legitimately, and there are various legitimate ways of achieving architectural success. The heiress method has much to commend itself and is extremely popular. For an ambitious, hard-working man there is no surer or more delightful path to success. The self-complacency of the successful architect is delightful to study. Self-complacency is a general characteristic of architects of all classes; even the most disappointed has an inward conviction (though he may never breathe it to any one) that he is not only the most ill-used man, but an entirely unappreciated one. The successful architect need have none of these feelings. He knows that he is successful and he is justified in knowing it. He will probably tell you so, and point out the strong points in his work. And he is entirely justified in this also; if he does not know where his work is strong it will be essentially weak. If he cannot tell when it is good and why it is good, he certainly will not recognize any deficiencies if other people tell him of them. There can be no harm in knowing all this, and if he were not successful he would not know it. An advantage the successful architect possesses over all other architects is that he can go on his road rejoicing, with numerous clients and fat fees, utterly regardless of the complaints of the critic. If there is one thing other than his bank-account he is to be envied for it is this.

THE sensitive architect is a delicate flower, too fragile for this world, too retiring for the harshness of business, too refined for contact with rough men and women who imagine that they can command his fine artistic gifts for 5 per cent. Of course the sensitive architect always has fine artistic gifts. That is part of his sensitive nature. He cannot bear a hard word, he cannot read an unfriendly remark about his work, he cannot stand being told he ought to do other than he does. He pours out his artistic spirit in abundance upon all the work that passes through his hands. He either is a hard worker or is indifferent to labor, lest he injure his delicate organism by overwork. If he is in earnest he will not spare himself. He is easily upset. Even though he has attained success,—and, delicate as the sensitive architect may be, he may still be able to resist the buffetting of this world long enough to mount to the utmost pinnacle of fame,—he never loses his prevailing characteristic. He is always sensitive; though he be not artistic he will still be sensitive. Properly speaking, his temperament is not suited for business. He has hardly his own proper space in this rough, rude world. But he stays in it, seeking success, striving, working, earnestly, zealously. When the artistic is largely developed in the sensitive architect, he will keep his sensitiveness developed by the ardor with which he works. He will realize that he is an artist, plunge himself into artists' moods, forget that architecture has a business side, and perhaps give more for his pay than he need to. All this is very commendable, though the laborer is worthy of his hire and should exact every cent he can collect. But it is not proper to speak of cents in connection with the sensitive architect. He is above such vile associations. He may live for his art, but above all he seeks to cultivate his sensitiveness. Therein he makes a great mistake. Sensitive men are not for this world. It is the hard-hearted, hard-cheeked who succeed. And we are all in the world for success. When the sensitive architect has obtained it he deserves hearty congratulations, for he has done what many of the rougher of us have not.

THE engineer-architect is a creature of very different caliber. Collectors of architects will find him a difficult species to retain in their collections. As like as not he may have become an architect only because he could not get a job as an engineer. He may thrive, since, as every good building must stand upright, he can usually refer to his preliminary training as a special reason why he can build better than those trained otherwise,—the sensitive architect for instance. But he should not do so. Early training is speedily forgotten, and the engineer can only become an architect after he has carefully forgotten a good deal he first learned. He may not want to do that. He may be filled with a sense of his own importance. He may lay down rules of his own manufacture for guidance in every condition under the sun, and forget that architecture is not like engineering, where everything may be mathematically calculated. It is usually difficult to convince the engineer-architect that he is not always right. He is so accustomed to calculating and revising calculations that he does not know a stage in which he may be shown to be utterly wrong. Of late years he has become a well-established personage, and, in the intrusion of architecture upon the field of engineering—has found what he imagines the ultimate form of architecture. Usually he knows more of architecture than the architect; at least he will tell you so. And he may also, in confidential moods, tell you he is the best engineer you happen to know. Probably he is right; at least he is no worse than the architect who will tell you that you know no finer architect than himself. Thus are engineering and architecture united, and thus are the traits of one shown in the other. By himself the engineer can do the very worst things in building. When he calls himself an architect he may be better, but if he does it may again be only because he has done the worst he could before he became an architect. The engineer-architect is the antipode to the sensitive architect. It would be interesting to see the twain in harness together, but it would be very sad for the sensitive man. Sensitiveness cannot fight; it is contrary to its nature. The engineer is usually of a hardier mold and stands not upon ceremony. On the whole, there would appear to be no reason for looking upon him with regard. He may be a good, useful fellow, but he would probably make a better engineer than architect. And is it not written, "Ye cannot have two masters"?

ALL the world does not contain a sadder spectacle than the soured architect. The disappointed man in every walk of life is entitled to the utmost sympathies of his fellow-men. The soured architect is quite likely to have an artistic, sensitive nature. He has started out in life with the utmost hopes of success. Bright dreams of triumphs filled his mind. Fine artistic conceptions floated before his eyes. All the world was bright and gay; life was full within him; success was within his grasp. Then, perhaps, something happens. His first work may not be quite what was hoped for. He may not be satisfied with it himself. He may not have pleased his clients. Even the first work may not have come. This sometimes happens, and the young man eats his life out in bitter disappointment. The world wags round and his practice grows no larger. Hope—blessed though it is—dies hard in some breasts, and hardest of all in the artistic breast, such as the hopeful architect's usually is. Dissatisfaction sets in. The world is no longer as bright as it was. The gaining of a livelihood is too hard a task for a delicate nature. The world is not only not bright; it is positively gloomy. Fewer and fewer become the clients. Men who do no better work, who do not do half so good, are growing rich. There are abundant opportunities for all but him. Can he be blamed for his misanthropy? Can he be censured for thinking ill of a world that has ill-used him, that has, perhaps, sinned against him more than he has sinned against it? Must his work always be condemned, must it always seem bad, even though he has put the best that is in him into it? Only the most heartless nature would hold such a career up to scorn. Only the most thoughtless would find delight in dragging it out into the harsh glare of the sun that has for so long refused to nourish it. There are many such men. Perhaps not more than in other professions, but success in architecture is obtained under such difficult conditions that you are apt to run across them at every street-corner. The successful architect, the sensitive architect, the critic, all men who come in contact with the disappointed architect, should have nothing but a good word for him. He deserves all the kindness in a world that has refused him everything. It is easier to become a disappointed architect than any other. May he find in the next world the comfort, the success, the rewards he has sought in vain in this.

THE bad architect is usually unconscious of his wickedness. Often his practice is entirely disproportionate to his abilities, and it is quite likely to happen that the very worst will have the greatest number of jobs, and the largest commission list. Fate sometimes ordains that such should be the case, and the man who least deserves success obtains its fullest measure. When the bad architect sins he usually does it in a thoroughly wholesale and barefaced manner. If you ask him for a good piece of work he will produce something appallingly horrible. It is a literal case of asking for bread and getting a stone. And of course as your client is never aware of this, it is possible for a thoroughly bad architect to build up an immense practice out of pure concentrated badness. You doubt it? Then you live in a singularly fortunate city. The bad architect is, in fact, the natural product of a society in which architecture as a fine art is not appreciated. Very few people know what architecture really is; fewer still appreciate it. So it thrives in badness and the bad architect waxes in wealth. He may not mean to be bad; sometimes he can do good work, but evil things seem to come naturally to him; he never seems to realize when he is truly and utterly bad. And so long as architecture is unappreciated by the people who pay for it,—so long as people can be found who will measure art by cost, or by size, or by anything but a genuine artistic standard,—just so long will the bad architect flourish. He teaches some useful lessons. He tells us, first of all, what not to do, but when he has told us that some countless times and never applies the lesson to himself—never seems conscious there was a lesson to learn—it becomes more than sad. For each of these lessons, mind you, is carefully encased in stone or brick or iron, and is intended to last some time. Instances have been known of their surviving the architect himself, and remaining in full flower of horror long after he has been forgotten, save for them. But there are good times coming. The bad architect cannot flourish forever. It may be years before he disappears, but he must go some time. He could readily be dispensed with. His most exaggerated form is when he stops doing good things and takes up with bad ones. There is a consistency in a man who perpetually does what he ought not to do that can sometimes be forgiven; nothing better is expected of him. Like the criminal who has been brought up in a criminal atmosphere from his earliest days, he has some excuse for his crimes. On the other hand, no punishment can be too severe for the cultured, well-meaning, well-trained man who falls deliberately. So the architect who can do good things, yet doth bad ones, deserves a severer punishment than is measured out to the habitual sinner.

THE trumpet-blowing architect speaks with no uncertain voice. Of all sorts he is the most complacent. He not only knows his own worth, but he is determined that every one else shall know of it. He misses no opportunity to hump himself into public notice. He forms connections of every sort. He hobnobs with politicians and—when he can get the chance—with the 400. He joins associations; he makes connections of every sort. Nothing that can proclaim his merits aloud is neglected. All are used, and used for his aggrandizement. And this is not unnatural. If one does not blow his own trumpet no one else will do it for him, save a complacent critic. The faddic critic is the only instance we wot of in which one's own personal, private, peculiar trumpet will be performed on gladly, loudly, and willingly by another person. Whether the blower finds satisfaction and compensation in it is not made public. But the genuine trumpet-blowing architect will scorn such methods as these. Rather than resort to such subterfuges he will stand out before the public,—upon the stoop, if a housetop be not available,—and shout his merits aloud. It is very useful work, albeit somewhat wearing. He is more familiar with the subject than any other living soul, and, as the tendency of modern journalism is towards specialism, it is quite in the usual line that he should speak only of himself. He is usually a strong-minded person, for shrinking souls cannot get up before a scoffing world and tell how great they think they are. And, being strong-minded, he will not hesitate to speak strongly of himself, that being a subject on which he thinks and feels strongly. All of this is very proper, though it may become utterly wearying at times. There are methods of trumpet-blowing not so offensive as others, but when it is offensive it is usually very much so. The competition for business is now so sharp among architects that the trumpet-blowing species has become a recognized variety. He may not be yet wholly distinct; he may not yet be unpleasantly numerous, but he exists. His rarity, indeed, helps to emphasize his blowing qualities and renders him more conspicuous. At least he has the merit of wishing to be as conspicuous in other people's eyes as in his own. He would not keep his goodness all to himself. That portion of the earth at least he is willing to give away. He is not wholly hoggish. Let us give him credit for what generosity he displays.

AND the Ecole architect. What a fine bird is he! If we have reserved him until the last it is rather with the same sensation that we would put the delicacies of a dinner at the end rather than at the beginning. Besides, shall not the first be last and the last first? The Ecole architect wraps himself in a mantle of Ecolism. He does work, as a rule, exactly as he would do in Paris, and with a fine Parisian touch that is both delightful and inspiring. First and foremost, he puts his beloved Ecole. No alumnus was ever more faithful to his alma mater, though he may have spent but a year or a few months at it. His fidelity is, in fact, only equalled by that seen in certain domestic animals for their masters. He is not content that he himself shall be an Ecole man; every architect who is an architect must do likewise. This is generous, for some men would keep the *creme de la creme* to themselves and not be so harshly judged either. If a young man in search of architectural knowledge presents himself to the Ecole architects, they forthwith begin to shout with one voice "Paris! Paris! Paris!" and they raise so great a tumult, they bring so many arguments to bear, they show how great they expect to be,—they point out the good it has done them, they talk, they argue, they relate incidents, they point lessons,—until the young man has no choice. These are his preceptors, his friends, his guides. He has known them from his youth up. If he would be as great as they hope to be he must follow the same paths. And so he girds up his loins and sails gayly away to the shores of France, where many a bright youth has gone before him, where many happy minds have sought fame and fortune, and......This is the distinguishing trait of the Ecole architect. He may be successful, he may be sensitive, he may be given to blowing on his own trumpet, he may even be disappointed, but whatever his state, whatever his fortunes may have been, he is first, last, and all the time an Ecole architect. He never realizes that what may be well for one may not be good for another. He may not see that systems of one land may not answer for another. He has tasted of the forbidden fruit. Henceforth he would devote himself to it, and have all do likewise. He knows no higher praise than to be called an Ecole architect. And more, he would rather be an Ecole architect and fail, than succeed without being an Ecole man.

RAILWAYS

Conducted by Thomas L. Greene.

IN a general survey of the railway field perhaps the most important thing to be mentioned is the action of the western railway presidents in forming an association which in effect takes from the traffic officers the power of changing rates, and makes the presidents themselves directly responsible. That the situation called for such an unusual remedy is sufficient evidence of its seriousness. The hard times are felt by the carriers as by other business interests, in the loss of traffic. To add to such losses the cutting-down of the receipts below cost through fierce rivalry is not only unnecessary, but is a positive disadvantage to employés and to all those who are dependent directly or indirectly upon the continued and prosperous operation of the railway system for their trade. The railways form so large a part of the industries of our country that when they are struggling to escape insolvency, every other industry suffers with them.

But it it impossible that there can be such solution of the rate-cutting problem as these presidents propose, without a preliminary understanding as to the conduct of the general business and the share in it which each member is entitled to have. In short, the presidents cannot hope to continue doing the traffic-manager's work in addition to their own unless the way is made clear to them through a modification or repeal of that section of the act to regulate commerce which prohibits pooling. The house committee on commerce at Washington has reported a bill to allow of such pooling under the approval of the interstate commerce commission, accompanying it with a report which certainly sets forth the necessity for such a law very clearly. That the sentiment in favor of pooling is making progress is evidenced by the resolution which was passed at the May convention of state railroad commissioners in Washington. Though opposed by the commissioners of certain southern and western states, the resolution was adopted by a vote of 15 to 8 after an excellent paper by Commissioner Dey, of Iowa, and the tacit approval of the interstate commerce commission itself. When fair compensation can be secured to the railways by some such law, we may expect that the companies will again take up the question of improvement to their equipment and road-bed with the purchase of the supplies necessary therefor.

Yet, while we are looking for permissive pooling, we should not forget that the railway associations as they stand are great helps toward the maintenance of rates. The foolishness of the rate war in the south is shown by the statistics of comparison between the southern states and the lines in the so-called "Granger" commonwealths. The number of miles of railway per acre and per inhabitant are twice greater in the northwestern than in the southern states. In spite of this larger proportion of railway mileage, the traffic per mile in Minnesota, Iowa, and Wisconsin is greater than in the states south of the Ohio river, while the average rate per ton-mile is also slightly higher. The sparseness of population in the south and the less number of miles in proportion to territory and population are accounted for largely by the average yield in pounds per acre of the different crops. The census figures for 1889 give this average yield per acre: for cotton, 177 pounds; for corn, 1648 pounds; for wheat, 840 pounds; for tobacco, 702 pounds; for rice, 800 pounds. With such great differences between the traffic to be received from an agricultural acre in the two sections, it is a matter of surprise that the average rates in the south should be lower than in the northwest. If this is true when the regular tariffs are adhered to, how much more true it becomes when the southern lines are foolish enough to cut their rates heavily. Public opinion ought not to sustain such a rate war, at least until the machinery of the Southern Railway and Steamship Association has been used to bring about a peaceful settlement of the disputed questions by arbitration.

MUCH of the success of modern railroads depends upon the number of tons which the management are able to crowd into a freight train. The average of the southern roads just mentioned is about 160 tons per freight-train-mile while that average in the northwest is about the same. If the average could be made 200 tons, a saving of train expenses would be very great. Companies whose average receipts per ton are small can succeed in holding up against their expenses only by increasing the lading of their trains. The soft-coal roads are conspicuous instances of this necessity. As an instance, the Columbus, Hocking Valley and Toledo Railroad Co. report that over 70 per cent. of their tonnage consists of bituminous coal. As this was all moved in one direction their empty car mileage was 44 per cent. of their total car mileage, while the average receipts for all freight were but six mills per ton per mile. In spite of these great obstacles the company report a fairly prosperous year, success being attributable to the fact that their average train-load was 400 tons. As this average includes the hauling of the empty cars and trains back to the mines it will be seen that the actual lading of a coal-train from the mines must have been very heavy. President Waite is unquestionably correct in ascribing these large figures of train-loads to the increased capacity of cars and engines and the reductions of grades. In like manner the recent history of the Chesapeake and Ohio railroad is one long story of the liberal expenditures of money upon road-bed and equipment in order that long trains of coal may be hauled 400 miles to the seaboard over the Allegheny mountains at the extremely low rate of 3.27 mills per ton-mile; yet the average lading of freight-trains was 283 tons, and the average earnings per freight-train-mile were $1.44, —enough to pay expenses and leave a profit.

While upon this subject it is interesting to note the study of the ratings of engines as told in the St. Paul *Pioneer Press.* It is customary with most roads, we suppose, to estimate the capacity of their freight-engines by the number of cars which they will haul; yet undeniably more tonnage can be handled by an engine where the weight is compact. An engine may haul 750 tons in thirty cars while the same engine may haul 100 tons more if in twenty-five cars. One Minnesota road has carefully mapped out its main line in engine runs, giving the capacity of its locomotives in tons, it being expected that the operating officers will see that each engine is loaded to its capacity in tons rather than in number of cars. The *Pioneer Press* thinks that the system is one which sooner or later must become universal, and indeed it affords a valuable hint to those whose business it is to study transportation economy.

THE proposed reorganization of the New York and New England railroad has had an influence upon railway rehabilitations out of proportion to the importance of the road. The two classes of stock of this company were assessed $20 and $25 per share each, only part of which was represented by new stock in the new company. Such a drastic assessment has had the effect of directing financial opinion to the undeniable fact that the shareholders in a corporation are the ones who must bear the brunt of a failure, since they and they only are to share in a large profit should such be attainable. It is too often forgotten that a mortgage is put on a road for the benefit of shareholders as a cheap and easy way of raising that much capital which is to be paid only a certain rate of interest, leaving all the profits over and above that rate to the stockholders. In short, bondholders are creditors of the company without interest in its success except as that may effect the security of the mortgage; while the stockholders are partners in the enterprise, entitled to the profits and liable for the losses. By a combination of circumstances certain reorganizations in the near past have been carried through successfully, although they asked sacrifices on the part of the bondholders without proportionate demands upon the shareholders; but it is doubtful whether such procedure is any longer possible. The New York and New England reorganization plan and its success will have a marked influence upon reorganization plans in the future.

THE standard set for public men in England is still high. Mr. Mundella was president of the Board of Trade, a semi-official governmental body somewhat similar to our state railway commissions. It was found that Mr. Mundella was a director in an industrial enterprise whose acts were subject to suspicion, and whose affairs were brought before the court. The judge administered a rebuke to the president of the Board of Trade for allowing his name to be connected with an enterprise which, under suspicious circumstances, inflicted loss upon the investors. The gentleman, in deference to the public opinion expressed by the judge and by the leading journals, resigned his presidency. The doctrine that every public official should be free from even the suspicion of connection with fraudulent concerns is one which should be more carefully lived up to.

LAST month in this Department mention was made of a valuable official report upon the railways of South America, prepared for the Uruguayan government by Don Juan José Castro, an eminent civil engineer of Montevideo. Don Castro has since become minister of the interior with the incoming of a new administration in Uruguay, a fact which promises well for the continuation of the progressive policy pursued in that republic. It is especially fitting that the incumbent of such an office should bring to it such a technical training as to fit him to deal intelligently with projected railway and other engineering enterprises.

In this connection it is pleasant to announce that the Central Railroad of Brazil, through Messrs. Charles R. Flint & Co., of New York, have placed with the Brooks Locomotive Works of Dunkirk, N. Y., an order for sixty locomotives,—thirty passenger and thirty freight. The order represents nearly three-quarters of a million of dollars. Tenders of English engines were made to the railroad, but the government decided to give the order to United States makers. The requirements are for the best and most modern work. Following the statement quoted last month from the report upon the railways of South America by the Uruguayan government, that progress in South America is best attainable through the use of American practice and American methods, this large order is an evidence that the South American field is open to such of our manufacturers as will study its requirements.

THE unprecedented shipments of wheat from the Argentine Republic to Europe which have played such an important part in fixing the present low prices of American wheat, have caused the Argentine railways some embarrassment. To find storage-room they have been obliged to utilize all the buildings they could find, including some of their own station-houses and the like. Mr. F. W. Barrow, general-manager of the Buenos Aires Great Southern railway, has been in the United States for two months studying the American system of operating railways. Mr. Barrow speaks in the highest terms of American methods, as well as the facilities offered him by the railway officials in obtaining information. He believes that the Argentine Republic will become one of the greatest wheat-growing countries of the world, because of the large area of valuable land, the richness of the virgin soil, and the low price of labor, which averages about $10 per month. Mr. Barrow is convinced that American operating principles and methods are better suited to the Argentine railways than the British. All signs point to the growing favor with which American methods in transportation and American machinery are regarded in South America.

THE *Railroad Gazette* prints an interesting statement of what it calls the "consumption" of equipment. By comparing the number of locomotives, passenger-cars, and freight-cars on the books of the Lake Shore and Michigan Southern railway in 1870 and in 1893, after adding the cars and engines meanwhile purchased and built, it is found that on the average 5.4 locomotives, 4 passenger-cars, and 352 freight-cars have disappeared per annum. Meanwhile, the mileage has increased from 1013 miles to 1460; the percentage of equipment destroyed or sold per annum being 1.2 per cent. for locomotives, 1.2 per cent. for passenger-cars, and 2.6 per cent. for freight-cars. This consumption of equipment is much lower than on other roads, for the reason that the management of the Lake Shore has made large outlays for improvements in grades and alignments and has, in consequence, repaired its equipment longer than other roads which have been spending their money for larger cars and engines. What other company in proportion to its business can show as small an annual destruction of equipment as the Lake Shore?

THE convention of state railroad commissioners in Washington in May decided to abandon all attempts in the public accounts to distribute the expenses of operating between passengers and freight. Figures of this sort are of course worthless. Any attempt to divide general expenses must fail, and if any use was to be made of the approximation when arrived at as a basis for fixing rates, it ought to fail. If the sheep-farmer cannot divide his farm expenses between the wool and the pelt, so as to show which of the two yields the most profit, it is useless for the accounting officer to try the same thing in the complicated accounts of our railways.

RECEIVERS' certificates were originally intended to be issued as an extraordinary remedy. The courts looked with suspicion upon every application for such an unusual method of raising money. It was seen that receivers' certificates put another lien ahead of the mortgages which, by their terms, ought to have a first claim upon the property. Hence, it was argued the courts ought not to allow any other debts to come in before them. But gradually a broader view prevailed. It was seen that receivers' certificates represent the commercial conditions; that when the lien of the mortgage has become impaired by losses in operating the road, the issue of certificates to represent those losses does not change the situation. Now it is customary, on the application of those concerned, for the courts to allow the issue of receivers' certificates for any object which is shown to be for the benefit of all concerned. A striking instance of the change in the sentiment regarding receivers' certificates in practice, is that of the issue of $1,000,000 in order that the interest on the first mortgage bonds of the Northern Pacific railroad, due July 1, should be paid. The holders of the bonds of this railroad junior to those of the first mortgage through their committee asked the court to be allowed to lend this amount of money to the receivers for the purpose above stated, and to take therefor receivers' certificates. As these certificates are a lien upon the property after that of the first mortgage, it is seen that the junior bondholders have loaned this money practically on the same security as that covered by their own bonds. This loan was arranged for to prevent a default of the first mortgage which would have still further depreciated these junior bonds. It was conceded that the road had earned the interest on the first-mortgage bonds from its operation, but that the money had been appropriated by order of the court to pay off the claims for wages, supplies, and current expenses incurred previous to the receivership.

MINING AND METALLURGY

Conducted by Albert Williams, Jr.

IT is a matter of common remark, and also a matter that is beyond dispute, that the average character and tone of the precious-metal miners in the far west have been steadily deteriorating for years. Making due allowance for that peculiar human weakness which leads us all to magnify the "good old times" simply because they are old times and are viewed through the illusion of false perspective, there is no denying that the race of miners, taken as a whole, is degenerating. The explanation is simple, though perhaps not what might be anticipated by those who have not been on the spot to observe the change. Civilization and the railroads are to blame. Both are good things. Both have helped mining. Yet in this particular they have done harm. As the railroads advance and transportation becomes easy and cheap, and as the means of subsistence and the comforts of life become more accessible, the hardy pioneers and the enterprising, intelligent miners give place to an inferior set of men, in great part not miners at all either by instinct or by training, who always follow and never lead. Some persons have the mistaken idea that a new mining-camp in an out-of-the-way, unsettled region is always the scene of violence and disorder. This is not borne out by the facts. In such places there are often a few desperadoes and the usual fringe of undesirable parasites, but the general tone of the community is wholesome. The men are there for a purpose, and only enterprise, fortitude under privations and hardships, and thoroughly manly qualities, have brought them there. The farther away from a railroad and a base of supplies, the more rigorous the climate, the greater the natural obstacles, the better the men. The writer has seen many such new districts at a time when the nearest railroad was hundreds of miles away, and when it required some little "initiative" and resource to get there. The first-comers, as a class, were always men of whom the country could well be proud, men capable of doing their own thinking. That they were not chronic strikers, intimidators of workers, dynamiters and destroyers of property, certainly was not for lack of independence. But just as soon as the railroads came they brought an entirely different type of incomers. This has always been so. The California pioneers, usually depicted on the stage and in novels as an uncouth, red-shirted, lawless crew, were in reality an orderly and generally superior set of men. While they sometimes took the law into their own hands, it was from necessity and for the sake of order and the common safety. The early adventurers in Colorado, in Idaho, in Montana, and everywhere that pluck and push were needed, were of the same type. But now the railroads go almost everywhere, living is cheap, there are no hostile Indians to face, and the high qualities once to the fore are no longer demanded. Hence an influx of men not naturally miners but laborers, and a gradual extinction of the old type. Here is another instance of how civilization sometimes advances backward.

WITHOUT power-drills and modern high explosives many of the engineering feats of the day, now becoming so common as to attract little notice, would be, if not impossible, at least economically impracticable. The development of the drills and of the explosives has gone on with equal steps, and in both directions very rapidly, so that the whole system of tunnel-work has been revolutionized in less than twenty-five years. One of the most notable of recent tunnels is that of the Niagara Falls Power Co., which is a tail-race starting just above water-level below the falls, running under the village of Niagara at a depth of 200 feet, and discharging 7250 feet from its head. Mr. A. C. Rand furnishes the following particulars: The grade of the tunnel is 36 feet to the mile; it is 19 feet wide, and 24 feet high inside the brickwork. The sinking of the shafts was attended with many difficulties on account of the large amount of water entering them, but when they were completed the entire tunnel was excavated in the amazingly short period of six months. The boring was done with power-drills driven by compressed air and was conducted in three benches, the upper one, or heading, being driven first in advance, the middle bench slightly behind, and the lower one last. The excavated rock from the upper benches was withdrawn over platforms, thus permitting simultaneous work on three levels without interference. The cost of the excavation alone was $400,000, and, when walled with arching of brick, $1,000,000. In driving this tunnel, three shafts were sunk in order to expedite the work—one at the portal, 92 feet deep to the tunnel soffit; No. 2, 2650 feet from the portal, 260 feet; No. 3, 5200 feet from the portal, 160 feet deep.

IN the May number of this Magazine (p. 297) Dr. Henry Wurtz offers a suggestion for the preservation of metals subject to corrosion by mine-waters which is worthy of serious consideration by managers who have had trouble on this score. In brief, the plan advocated by Dr. Wurtz is that of electric polarization, it being well understood that the corrosive action is an electro-chemical one rather than a simple solution or oxidation of the metal, and "if a mass of iron is exposed to the corrosion produced by superficial or internal voltaic currents, such metal is to be made, as a mass, the negative terminal of a much stronger current, from a dynamo-electric engine, while the corrosive liquid is made to bathe the positive terminal of such stronger circuit." Dr. Wurtz proposes that a small generator, operated by some small water-power (or perhaps the main pumping-engine), which will work night and day, is to be provided. The positive pole would be carried through an insulated wire down to the lowest sump, terminating in a body of hard-burned coke, while branches of insulated wire would connect, as a negative pole, the pumps, pump-columns, track, iron ladders, and other fixtures, besides which Dr. Wurtz thinks that the movable apparatus (as iron or steel cars, power-drills, etc.) could be temporarily put in circuit. In cases where the trouble is very serious, as is often the case, the inconvenience of the proposed remedy would not be prohibitory. It is of course not the ordinary rusting of iron and steel underground that is here referred to, but the far more destructive action of certain mine-waters, due mainly to the presence of copper and other sulphates derived from the oxidation of pyritous minerals as the mines become open to the air. Several other plans for protection or prevention have already been indicated in these columns, as, for example, the thorough tarring or asphalting of the exposed iron and steel, besides which there are the substitutes of copper, bronze, brass, and one or two special alloys for underground machinery and appliances. In this connection it is worthy of note that the great hydraulic pumping-engines at Clausthal have their cylinders, rods, and pumps all of brass, and makers of underground machinery in this country also use one or another of these substitute metals or alloys for some of the most easily injured working parts. But Dr. Wurtz's proposition is more radical. It does not involve any great expense, and it should certainly be tried when there is little doubt that the plan would work. If applied successfully to the pumps and pump-columns alone, that would be a great achievement.

MONDAY is proved to be the most dangerous day for fire-damp explosions, at least in those collieries which are not operated on Sunday, and this is the prevailing custom all over the world. The explanation is simply that during the suspension of coal-mining the ventilation is likely to become disarranged. Mr. Fairley in his recent work on ventilation * quotes some statistics from the report of the Prussian fire-damp commission, from which it appears that of 1666 explosions recorded,

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* *Mine-Ventilation Made Easy.* By William Fairley.

they took place, according to the days of the week, as follows: Sunday, 44; Monday, 327; Tuesday, 271; Wednesday, 240; Thursday, 275; Friday, 259; Saturday, 252—the figures running about evenly for all of the week days except Monday. On the same principle, after holidays or stoppage from any cause more danger of gas explosions is to be expected. The obvious lesson is that, on resuming work after such temporary suspension, especial care should be taken in examining fiery mines for gas before sending down the men.

Of all the states of the Union which have mining-laws—and there are at least seventeen states thus provided—Pennsylvania takes the lead in point of minuteness and completeness of such legislation. As a rule, official intervention in private industries is to be deprecated and shunned, for the intelligent self-interest of individuals and corporations is a more trustworthy safeguard than any official supervision and control. If there is any exception to this axiom it is in the case of laws designed to protect life and property, and this is the object of the mining-laws to which reference is now made, for those laws which apply to the ownership and title of mineral ground are for the most part confusing and a hindrance to mining enterprise. But the Pennsylvania code, which relates to anthracite and bituminous mines separately, and the strict system of inspection under it, have been justified by the result, as has also been the case in Prussia, Great Britain, and France, where much attention has been given to the matter. While the mining accidents in Pennsylvania continue to be deplorably numerous, they have slightly decreased in proportion to the tonnage raised and the number of men at work, notwithstanding the increased difficulties and dangers attendant upon deeper and more extensive workings. The improvement is particularly noticeable in those classes of accidents (such as explosions) where supervision has its best opportunity for good. Minor accidents due to carelessness are almost beyond control. Reading over the reports of the inspectors of the several anthracite and bituminous districts, one cannot fail to be struck by the conscientious, businesslike tone of each and all of them. The Pennsylvania mine-inspectors evidently understand what is demanded of them and are thoroughly in earnest in carrying the law into effect. Sometimes their zeal brings them into conflict with mine-owners and managers, but on the whole they have the hearty support of both employers and employed. All honor to these brave, hard-working men!

In the last complete report of the Pennsylvania mine-inspectors, Hon. T. J. Stewart, secretary of internal affairs, commenting upon the fact that the number of accidents is much larger in proportion to the number of men employed, and also for the quantity of coal mined, in the anthracite than in the bituminous regions, says: "The anthracite mines are much deeper and in many respects are of a far more dangerous character than the bituminous mines. The greater number of accidents therefore is not in consequence of less care and skill in conducting mining operations, but is the consequence of the greater natural dangers. While the mines in some portions of the bituminous-coal regions contain large quantities of gas, other mines are almost or wholly free from it, while no anthracite mine is wholly free from it. Besides, it is far more difficult to ventilate the anthracite mines than the bituminous."

It may be added that the greater amount of gas in anthracite than in bituminous coal-beds, other things (such as depth and the retentive character of covering) being equal, is an argument for, and may be explained by, the accepted theory that gas is not now being produced by chemical changes in the coal, but is merely retained in the pores and seams of the coal and possibly occluded in the more solid portions, ready to be given off when the workings and falls allow. For, if the bituminous coal were still slowly changing to anthracite, the reverse would be the case; while it is easy to understand why the anthracite having parted chemically with most of its volatile matter, should still retain it mechanically.

THE failure of the 18-inch Harveyized nickel-steel armor-plate, at its recent trial at the Indian Head testing-ground, was a complete surprise, former trials of thinner plates having been so very satisfactory. The test-plate represented the side-armor for the battle-ship *Indiana.* It was 16 feet long, 7½ feet high, 18 inches thick from top to middle (corresponding with the water-line), tapering to 8 inches at the bottom. The first projectile, an 850-pound Carpenter shell fired at 100 yards with a muzzle velocity of but 1465 feet per second, badly cracked the plate in two directions; the second shot, a similar shell at 1926 feet velocity, wrecked the plate, breaking it into three pieces. The makers claim that there were evidences of a hidden flaw, and have asked for further trials, which will undoubtedly be made. The matter is a very serious one to the country, involving much more than the mere cost of the armor, for it affects the reliability of the whole system of armor-defense to which our government has committed itself, with the sanction of high ordnance and naval authority.

LIKE all new alloys and processes, nickel-steel and the Harvey method of surface-hardening require long and patient experiment and trial before all the contingencies are fully understood and provided for. In the light of past successful experiment with armor-plates made on the standard American plan, it is too early to lose faith in them because of a single disappointment, though it must be admitted that this failure throws suspicion upon accepted plates. The results of further trials will be awaited with deep interest.

THE "nickel-steel" used for armor is sometimes really a nickel-chromium-steel alloy, the nickel giving toughness, and a small percentage of chromium being added to increase the hardness. It is difficult to secure evenness of distribution of the nickel and the chromium. A correspondent of the *Engineering and Mining Journal*, writing over the initials "F. C.", makes a very important suggestion,—to supersede chromium by tungsten. Speaking of the present alloy, the writer referred to says:

> Theoretically, no objection could be raised, but as chromium is exceedingly brittle, counteracting the effect of the nickel, and at the same time very hard to melt, a lack of uniformity in the plates is almost unavoidable........If we can add another metal, capable of imparting to steel its hardness without annulling the effect of the nickel the ideal composition for an armor-plate will have been found. Fortunately, there exists such a metal.......tungsten. With steel, and even wrought iron, any degree of hardness can be obtained..... ...Tungsten is more fusible than chromium, and a more uniform mixture can be obtained; but even if it were not so, slight irregularities would not involve, I believe, such risks as are due to the use of chromium. In this case slight differences in hardness would be the only effect. Tungsten has been used in every kind of steel where at the same time hardness and toughness are called for; from the famous Damascene steel to our best tool and cutlery steel, all contain it in a greater or less amount, and its applicability to armor-plates is obvious. There are strong reasons also, it is said, for attributing the excellence of Krupp's armor-plates, whose composition is kept a secret, to the use of this metal.

EDITORIALLY, the *Engineering and Mining Journal* advances the hypothesis that in the making of these plates—and especially of very thick ones—internal strains are induced, which may have come from the manner of tempering or cooling, or from the temperature at which worked, and suggests that these internal strains may be only temporary, being greatest when the material is first turned out, and gradually diminishing as the molecules of the material rearrange themselves, until they come to an equilibrium, when the internal strain disappears and the piece can then resist to the full limit of which its material is capable. Certain observations seem to indicate that there may be a great deal of truth in this hypothesis, which, if correct, would relieve much anxiety.

SOME interesting information as to mining in China is furnished by correspondents of *Kuhlow's* (Berlin), but it does not offer much encouragement to prospective foreign investors, at least under present conditions, notwithstanding the known importance of the mineral resources of that country. Mr. John A. Church has already described, in this Magazine,* his experiences in superintending a Chinese mine, and this later correspondence of *Kuhiow's* is fully corroborative. Undoubtedly a great field for profitable mining enterprise remains to be opened there, but at present there are decided drawbacks. China is still nearly undeveloped if we consider it from a modern point of view. On the other hand, the Chinese have obtained ores and coal in the most primitive fashion nearly all over the country. The provinces of Yunnan, Szechnan, and parts of Hunan are rich in good copper-ores. Iron is found in Hunan Kwangtung, first-class ores in Shensi, Shansi, and Honan. Coal is abundant in all the northern provinces. It is sold in nearly all towns and villages for home consumption, near the places where it is found, as the total absence of means of transport does not allow the carrying of it to places more than say ten miles distant from any mine. The working of these mines is simply sinking a shaft in places where coal (and iron and copper just the same) is found near the surface, and abandoning it as soon as water drives the workmen out. Thus the coal gained is mostly soft surface coal, though on the north better coals than anthracite are found. Good coking-coal for use in iron-furnaces has not been found. In Manchuria very good ores of copper, silver, iron, and lead have been found of late. Copper, too, has been discovered in Kansua. There is no doubt a great field for mining enterprises all over the empire if taken in hand properly by strict management, appliances of modern machinery, and the necessary capital. Foreigners are at present not allowed to own any landed property in the interior, nor could such properties be mortgaged to foreign capitalists. This, of course, excludes all chances of foreigners opening and working mines. The only mines worked on modern principles and superintended, though not managed, by foreign salaried engineers, are in Chihli and Hunan. They are semi-official enterprises, and the parties interested are the leading officials and a few wealthy private individuals. Several mines have been started by means of Belgian, English, and German mining engineers, but have not been developed enough yet to enable anybody to judge the probable results obtainable.

KOREA has shown a more progressive spirit during the last few years, and has encouraged the development of its mineral wealth, welcoming foreign engineers and modern methods. This has been due to the ascendant influence of foreigners, particularly Americans, in state affairs. No very large investments are reported to have come from the outside, but, as in Persia, which also has latterly shown signs of activity in mineral development, what has been done has been mainly on government account.

IN the Witwatersrand (the "Rand") district of the Transvaal—the leading gold-camp of South Africa—the ore, a conglomerate, is crushed in stamp-mills, in which a part of the free gold is obtained by amalgamation and the auriferous pyrites are concentrated, generally by belt vanners, and treated by the chlorination and cyanide processes. The tailings (battery sands and slimes) are worked by the cyanide process. A well-conducted establishment obtains 55 to 60 per cent. of the gold by amalgamation; the rest that is saved is taken from the concentrates and tailings, and it is claimed that only 5 is lost. The average yield per ton in 1893 was 14 pennyweights, crude (worth $17.14 per ounce), and the cost of produced averaged $6.33 per ton, though under unfavorable conditions it was $9.50 and even more. The lowest record was $4.75 per ton. At the average cost of mining and treatment and selling price of the gold, a content of about 7.5 pennyweights is regarded as the usual lowest limit for profitable mining, though a few mines working under specially favorable conditions are said to have earned a slight profit on ore carrying only 5 pennyweights. Herr Schmeisser, the mining expert from whose official report to the German government the foregoing averages are taken, estimates the probable total output of the Rand deposits at $1,710,506,000 to a depth of 1200 meters (3957 feet), which would take forty years to work out; while Mr. Hamilton Smith, the California expert employed by the Rothschilds, estimated $1,014,000,000 to a depth of 3000 feet.

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* November, 1891, p. 196.

FROM the report of Mr. Williams, the American consular agent at Johannesberg, the following summary of the Transvaal gold production is obtained: To the end of 1893, the Rand district had produced 4,556,235, ounces (crude), and all the other districts (estimated), 500,000 ounces, or a total of 5,056,235 ounces. At $17 an ounce this would represent nearly $86,000,000. The output of all the Transvaal districts is increasing.

SAMPLING is an art in itself, whether applied to a mine, an ore-pile, a carload, a sackful, or the small samples and specimens to be resampled before assaying. Its importance seems to have been realized in a recent official examination of some iron-ore mines, though the method pursued, as described in the report, is not exactly that which would be adopted in usual practice. In the preface to the report in question, it is said:

> As it is well known, the representation of the quality depends as much on an intelligent sampling as on an accurate analysis of the same. Mr. ——— has endeavored, in collecting samples, to make them as truly representative as possible, by taking a great number of small chips, aggregating *from two to five pounds*, from the full cross-section of the ore-bed; and, where circumstances would not permit of this, he has taken similar samples from old dumps and heaps of ore lying near the openings, or from a great number of points along a general outcrop.

It would hardly seem to be worth while to devote the time, trouble and expense of making 175 (the number actually made) complete analyses of samples taken in this way. A complete iron-ore analysis is quite a tedious and elaborate affair, as any one who may have had to pay a commercial analyst for a set has found out. Samples taken in the manner described give an idea as to the character of the ore, but would not be accepted as a basis on which to sell a large shipment of ore, make a contract or transfer a mine, if the buyer should "want to know."

HERE is another little story about iron-ore: Once upon a time a geologist examined and reported upon an iron ore deposit. The ore appeared above a nearly level surface in the form of a small hill or mound, and that hill was, or was supposed to be, practically all ore. The report went to show how much this amounted to, and so, after stating the specific gravity of the ore (which was a highly scientific plan) it gave the length, breadth, and height of the hill as so many feet each way, hence so many cubic feet of contents, hence so many tons of ore in sight. An inquisitive reader, whose time was not very valuable, went over these figures and found that the extreme dimensions had been multiplied together to make what is called, for short, a right parallelepipedon. That is, the actual shape of the mound was disregarded, and the whole thing squared up, which would give a calculated result about double the reality.

SIMILAR methods have sometimes been adopted in estimating "ore in sight" under ground, and with astonishing results. One distinguished engineer, who ought to have known better, examined and reported upon the great ore body of the Consolidated Virginia and California mines, during the height of the Comstock bonanza excitement in 1874–75. He found $2,000,000,000 worth of ore "in sight." It happened that at the time there were long drifts and cross-cuts, raises and winzes, all in ore and in fact cutting through the heart of the bonanza. Taking extreme dimensions and multiplying them together and the calculated tonnage by the average tenor of the ore, which was there the richest, it was possible to figure out such a product. And many people believed in it. This was only an extreme example of a common fallacy. It has been repeated on a smaller scale in an endless number of reports.

CIVIL ENGINEERING

Conducted by John C. Trautwine, Jr.

THE long spell of exceptionally fine weather, extending over the latter half of April and the first half of May, has been followed, as everybody knows and as might have been expected, by a stormy season scarcely less protracted and of unusual severity. Pennsylvania, east of the Allegheny mountains, seems to have received the lion's share of the damage wrought by this visitation, including the sweeping away of dams, bridges, and other engineering works. At a recent meeting of the Engineers' Club of Philadelphia, Mr. Edwin F. Smith, of the Philadelphia and Reading railroad, in discussing the matter of damage to reservoirs by floods, urged the importance of providing impounding reservoirs with ample spillways, and of seeing that such spillways, after being constructed, are not allowed to become obstructed by the building of footbridges or in other ways.

A striking confirmation of this advice is found in the narrow escape of the Kittanning dam during the floods referred to. The dam, which forms part of the water-supply system of Altoona, lies near the center of the renowned Horseshoe curve of the Pennsylvania railroad west of Altoona, and must have been observed by every passenger rounding that curve and looking down upon the country below. The daily newspapers, indeed, report the destruction of this dam, but fortunately the facts do not bear out this statement. The dam, which drains a steep and wooded area of about nine square miles, has a spillway 34 feet in width and 5½ feet in depth; yet, owing, as it would seem, to a severe wind, occurring at the time of the heavy rains, as much as a foot of water passed over the embankment for thirty minutes, severely scoring the outer slope.

IT is gratifying to learn, from a circular issued by Professor James H. Smart, president of Purdue University, that the damage sustained by that institution from fire in January last is being rapidly repaired, so that, when the fall term opens, the apparatus destroyed will be replaced and ready for use. Advantage has been taken of the calamity to extend some of the existing features and to install new ones which will greatly add to the efficiency of the plant. A new building has been especially designed for the use of the locomotive-testing laboratory, the work of which has already rendered this institution famous, although the investigations thus far carried on have been confined to a single engine. The new installation is so designed that it can receive and test any locomotive whatever, and a new and specially-designed traction dynamometer is being constructed for this work by William Sellers & Co., Incorporated, of Philadelphia, while the Baldwin Locomotive Works, of the same city, are generously providing the two engines of a Vauclain compound locomotive for the steam-engineering department. These will be mounted as a stationary engine, and will be run by steam under the load of a friction-brake. The great Riehlé 300,000-pound testing-machine exhibited at Chicago will be added to the facilities of the testing department.

ALL hydraulic engineers know, and most of them appreciate, the now classic formula which resulted from the combined efforts of the Bernese engineers, E. Ganguillet and W. R. Kutter, and which is commonly known by the name of the latter. Some years ago Mr. Rudolph Hering, the well-known sanitary engineer, suggested to the writer the advisability of preparing a translation of the work * in which these authors describe in detail the development of their formula, and give directions and diagrams for its practical application. We accordingly undertook the work, and when it was well under way the writer visited Europe and made it a point to call upon Mr. Kutter, with whom most of our correspondence had been conducted. He was found occupying modest quarters in "the Pelican," a large but most unpretentious apartment house, most appropriately and picturesquely situated close to the banks of the Aar, and at the base of the cliffs upon which the town of Bern is perched. Upon his next visit, and after the death of Mr. Kutter, the writer called upon Mr. Ganguillet, who then still occupied his position as chief engineer of the canton of Bern, but who now, according to a notice received from his family, has gone over to his co-laborer, Kutter, having died at Bern on May 10, at the age of seventy-six years, and after a long and painful illness.

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* *Versuch zur Aufstellung einer neuen allgemeinen Formel für die gleichförmige Bewegung des Wassers in Canälen und Flüssen.* Bern: 1877.

In describing, in the Magazine for June, the replacing of the piers of the Iglawa viaduct, it was stated that the cracks found in the cast-iron tubes of the old piers were due to the unequal contraction of the iron and of the concrete with which the tubes were filled. It is claimed by those who are interested in the development of the modern concrete-and-iron form of construction that the two materials expand and contract with practical uniformity under changes of temperature; but, even admitting this, it seems quite possible that under a rapid fall of temperature the cast-iron shells of these pier-legs may have contracted upon their concrete cores and sustained considerable tension, if not actual rupture, before the reduction of temperature began to affect the concrete within.

Our attention has been called to a paper by Mr. Franz Pfeuffer, engineer of the railroad company, in the *Zeitschrift des Oesterreichischen Ingenieur and Architekten Vereines*. Mr. Pfeuffer treats with indignant scorn what he terms the unjustifiable and exaggerated reports respecting the condition of the old piers, and makes light of the report of the super-serviceable gensdarm that it was literally "raining" bolt- and rivet-heads under the bridge. Mr. Pfeuffer attributes the cracks found in the tubes to the rigidity of the roadway, by means of which the shocks of the rolling load were transmitted, without cushioning, to the piers; to the method of attaching the superstructure to the piers, by which free expansion and contraction were hindered; and chiefly to the presence of water which had penetrated between the concrete and the iron shells of the piers and which expanded in freezing. It also transpired that the tubes forming the old pier-legs had been cast horizontally, and that, owing to the tendency of the core to rise through the molten mass, the upper sides of the tubes, as they lay, were in some cases but little more than half as thick as the lower sides, and that these thinner sides contained longitudinal seams filled with slag which naturally rose to the top. In breaking up the piers it was found that besides those seams which had actually opened there were many more which were still closed, but which would undoubtedly have opened sooner or later. Before beginning the erection of the new piers, holes were bored in the old tubes at the ends of the longitudinal cracks, in order to prevent their extension and at the same time to allow any accumulated water to escape. About half of the original iron sleepers of the roadway were replaced with wooden sleepers in order to diminish the shocks upon the construction, and stout wrought-iron rings were bolted around the pier-legs. After this, but few new seams appeared. The authorities ordered the slowing-up of passenger-trains, but, as might have been foreseen, this measure, while it may have tended to the security of the viaduct, did not by any means tend to reassure the traveling public.

Iron tools accidentally dropped into the concrete within the pier-legs during the construction, and imbedded there, were found, upon breaking up the piers, to be entirely free from rust, while one wrench, which was surrounded partly by concrete and partly by cinders, was very badly rusted where it was in contact with the cinders, but preserved its metallic luster where it was in contact with the concrete.

MESSRS THEODORE ALTENEDER & SONS, the Philadelphia manufacturers of drawing-instruments, after a careful investigation of the advantages and disadvantages of aluminum in such instruments, have issued a circular stating that they find it unfit for such use unless so largely alloyed with other metals as to neutralize the advantage of lightness, which they consider a very doubtful one in such tools, however valuable it may be in field instruments. They find aluminum lacking in stiffness and in wearing qualities, easily abraded, so that it soils the hands and the paper, and unpleasant to use on account of a greasy feeling. The addition of a small percentage of aluminum, however, gives a whiteness, and perhaps an additional strength, to the metal which they have been using. They find aluminum for use in the manufacture of drawing-instruments only in cases where it takes the place of wood, as in making triangles and the handles of ruling-pens. The former are made of aluminum, and the latter of an alloy of aluminum and silver. To avoid the soiling of the paper by the aluminum triangles, their surfaces are coated with silver.

THE advancement of the requirements for admission to Cornell University suggests the ever-recurring question as to when we shall reach the limits of the increase of pressure under which we are working and supposed to be living. The struggle for existence is already so keen that those who achieve success are more or less certain, unless gifted with phenomenal constitutions, to become wrecked in the process. If the present rate of increase of the requirements of engineers continues, it will indeed be necessary before long, if it is not always so already, to kill one's self in order to make a living.

It has been suggested that the present tendency to specialization in engineering, as in all other work, tends to alleviate this pressure by reducing the amount of useless material with which the student is at present obliged to charge his mind. It is certainly much to be desired either that some partial relief of this kind may be found, or else that our entire economic strucure may be so remodelled that mankind may be enabled to live under more nearly natural conditions.

MR. GEORGE H. THOMSON, formerly bridge engineer of the New York Central and Hudson River railroad, has issued a set of specifications for structural steel for modern railroad bridges. Not content with waiting for the finished product and subjecting samples of it to tests to ascertain its fitness for bridge purposes, Mr. Thomson begins with the raw material in the ore-pile; and, after insisting that the manufacture, from the raw materials to the finished product, shall be conducted at one establishment, he goes on to provide for the inspection of the manufacture at every stage of its progress. Among the matters specified are that all ingots must be cast from steel melted in acid-lined open-hearth furnaces; that, in order to avoid segregation, no single ingot or casting shall exceed 15,000 pounds in weight; that all ingots shall be bottom-cast; and that no ingot shall be disturbed or removed from the position in which it is cast until it has become sufficiently solidified to obviate "bleeding." Plates and shapes are required to have an ultimate tensile strength not less than 58,000 and not more than 65,000 pounds per square inch, an elastic limit of not less than 38,000 pounds, an elongation in 8 inches of 26 per cent. for plates under 36 inches wide, and of 24 per cent. for wider plates, and a reduction of area of 50 per cent. The instructions to inspectors conclude with the significant words of Herbert Spencer: "Any test is liable to yield untrue results, either from incapacity or carelessness in those who use it"—a quotation which seems hardly up to the standard of rhetoric of that great writer.

IT would appear that the smaller towns, rather than the great cities, are, as a rule, the field for experiments in new departures. In a recent number of the *Journal of the Association of Engineering Societies* Mr. L. E. Chapin describes the sewage-disposal works installed under his direction at Canton, Ohio; and Mr. J. W. Kittrell now contributes to *Engineering News* an interesting and instructive account of the aëration and filtration plant installed under his direction by the Stanwix Engineering Co., at Ilion, N. Y., a town of only 4000 inhabitants. The water, which is taken from a small stream, is diverted by a low dam into an 8-inch main about 6000 feet long, which conveys it to a storage reservoir placed at a level 190 feet lower. Here the main terminates in a vertical jet, which, in winter, discharges through a plain nozzle, so that the water, falling back in a somewhat compact mass, serves to keep the neighborhood of the nozzle clear of ice. In summer the jet is provided with a fountain consisting of a central vertical half-inch jet, and of smaller jets arranged in circles around the center and inclined at different angles. The computed maximum discharge is nearly 900,000 gallons per twenty-four hours, and the maximum observed height of the center jet is about ninety feet. From the reservoir the water is led to two filter-beds about 300 feet further downstream and 51½ feet below the surface in the reservoir. The floors of the filter-beds are formed of a 6-inch layer of concrete resting upon a 12-inch layer of puddle. Next above the concrete is a series of channels in open brickwork, and upon these are laid, first, a 6-inch layer of fine gravel, and then a 30-inch layer of sand of uniform coarseness. From the filters the clarified water passes to a circular clear-water basin of 500,000 gallons capacity, the flow-line of which is nine feet below that of the filter-beds and 267 feet above the lowest portion of the village. The pipes in the gate-house are so arranged that the village can be fed from the stream or from the reservoir by way of the filter-beds and clear-water basin, or from the reservoir by way of the clear-water basin without filtering, or directly from the reservoir or from one or both filters directly. The total cost of the system, including some sixteen miles of pipe varying from 4 to 16 inches in diameter, 104 hydrants and 180 valves, but exclusive of real estate, right of way, engineering and inspection, legal and incidental expenses, was about $82,000. The cost of cleaning both the filter-beds, without renewing the sand removed, is $8.25. The cost of maintenance is estimated at about 2.7 cents per square foot per annum, or 82 cents per million gallons. The first marked decrease in the capacity of the filter-beds occurs about one month after cleaning, and appears to be due to the presence of a thin membranous film made up of matter held in suspension by the unfiltered water and forming upon the surface of the sand grains. Upon the reversal of the current in the filter-beds, this coat becomes detached and floats on the surface of the water in flakes sometimes as large as one square foot.

At the filter-beds of the Kew Bridge Works in London, the writer noticed, in 1889, that a somewhat similar system of brickwork gathering channels under the filter-bed had been originally used, but that these were afterwards replaced by open-jointed rows of drain-tiles, laid close together side by side over the entire bottom of the filter-bed; while in renewing the bottom of one of the oldest beds, both the brick culverts and the tile drains were dispensed with, and the bottom layer was composed of stones from three to six inches in diameter, the interstices between these being relied upon to carry the water to the central culvert.

IT has always seemed to the writer an absurdity that our communication with the suburbs of towns should be by means of ponderous trains and engines, such as would be used for transportation over long distances, a state of things which he can account for only by that mental inertia which so aptly leads us to follow in the lines laid down for us by our predecessors rather than to map out new ones for ourselves. The first steam-railroad lines were of necessity short ones, and thus the public mind became accustomed to the use of this cumbersome machinery for such light work, but now that the electric railway has evidently come to stay, it can be but a question of a very short time when local and suburban steam lines running heavy and infrequent trains will have been relegated to oblivion. Indeed it seems hardly possible that we should have long to wait for light electric overhead lines, with cars suspended rather than supported, and making very rapid and frequent trips between our great centers of population. The long-talked of St. Louis and Chicago line is a case in point, and something of the same nature, to connect the chain of great cities lying between Boston and Washington, would seem to be in order.

FOR years rumors of a trolley line between New York and Philadelphia have been floating about. At last they seem to be taking definite shape, but the shape is that of a line to be used mainly for local traffic. An elevated road over which light cars would be dispatched at short intervals and at very high speeds would seem to be the desideratum, and, seeing what rapid strides electric science and art have been making of late, we cannot help wondering that something of the sort has not been consummated.

THE development of the trolley system can hardly fall to exert a deterrent effect also upon the construction of elevated steam-railway lines in cities. The plausible argument that the speed of any surface system must, by considerations of safety, be limited practically to that already obtained by horse-cars, is found wanting when weighed in the balance of actual practice; for, even in tolerably frequented streets in our most populous cities, the trolley cars attain between crossings speeds very fairly comparable with those made on the elevated steam roads. Certainly, when we take into account the enormous difference in cost of construction and in damage to surrounding properties, the trolley road must appear as a formidable rival to the elevated road.

MR. WILLIAM A. PRATT, division engineer of the Baltimore and Ohio railroad, located at Philadelphia, has lately shown me a convenient table, which he has prepared and distributed among his trackmen, and by which they are enabled very readily to determine the radius of any existing circular curve. The table is based upon that arc of the gage side of the outer rail which is cut off by a chord forming a tangent to the gage side of the inner rail. The middle ordinate of this arc is therefore the gage of the track, 4′ 8½″. The table gives the length of the arc referred to, both in feet and in rail-lengths, and gives also the length of the chord in feet. In flat curves, where the arc contains a considerable number of rail-lengths, the counting of these lengths in the arc enables one to take the radius of curvature immediately from the table. In sharper curves, where the rail-lengths in the arc are comparatively few, it may become necessary to measure the chord, which may, of course, conveniently be done by a transit with stadia.

A PROJECT for the construction of a canal in western Tennessee, to connect the waters of the Mississippi and Tennessee rivers and thus to shorten by some two hundred miles the passage of boats from the Tennessee to the lower Mississippi, has been discussed at intervals for half a century, and it has been given some prominence recently by the daily papers of that section. Trustworthy accounts from the same region, however, indicate that the project is not likely soon to progress beyond the paper stage.

SOME years ago, as described in papers read by the engineer, Mr. L. L. Buck, before the American Society of Civil Engineers in 1881 and 1886, the old Niagara suspension bridge built by Roebling in 1852 underwent important modifications, iron replacing stone in the piers and timber in the trusses. More lately there has been some talk of replacing the entire structure. Mr. Hobson, engineer for the Grand Trunk railway and Mr. Buck have devoted some study to the matter, but a recent letter from Mr. Buck reports that nothing has been definitely determined upon.

MECHANICAL ENGINEERING

Conducted by Henry Harrison Suplee.

THE desirability of having some yielding point in a mechanical structure, so that if slippage or breakage occur it shall be in a known and unimportant place, is now an accepted feature in machine-design. There are, however, instances in which this point has been met in a manner the success of which is only really appreciated when its absence reveals how well it has done its work in directions not previously known. That belts will slip is well known, and that such slippage often materially acts to mitigate the violence of the shock which would otherwise occur in starting heavy machinery is also highly appreciated. The extent to which this action has reduced the injurious action of sudden stresses on line shafting has been more fully revealed, however, by the frequent breakages which have taken place in shafting when rope-transmission has been substituted for belting, all other conditions having remained unchanged. In an instance which recently came under the writer's observation this point was clearly brought out. The rope-transmission was one in which the driving-rope made several coils about the grooved pulleys, these latter being of wood ; and the power being delivered from the shaft in the same manner, there was no opportunity for slippage, as there would have been had belts been employed. Such an arrangement is really as rigid as is the hawser by which a boat is made fast to the post at its dock, and when any sudden shock comes upon a shaft under these conditions the only possible yielding is that permitted by the torsion of the shaft. The result was an abnormal series of shaft-breakages, these not being traceable to any especial shock, but evidently due to the repeated stresses producing torsional strains which became cumulative in their action, until the long-suffering shaft, like a piece of wire bent back and forth, broke under some load which would scarcely have affected it at all, had it not been the "last straw" following many others, each having contributed its share toward the final result.

IT is the importance of having some positive, yet gradual method of imparting motion in power-transmission which has led to the designing of the numerous forms of friction-clutches which are so widely known, and, with all due respect to those already in use, it may be hinted that the perfect clutch is yet to be made. For situations in which it is required that there should be either positive engagement or complete release, numerous forms have been made which are entirely successful, but when a heavy power may suddenly be thrown against a great resistance, and that too without the operator being able to exercise any proportional degree of judgment as to the graduation of the engagement, it must be admitted that there is room for the exercise of much inventive ability. Probably the shifting belt, with its fast and loose pulleys, is yet one of the best devices we have for this work, but every one knows how imperfect and unsatisfactory it is. In many of the western sawmills a slack belt, gradually tautened up to its work by a tightening pulley, has been found the most practicable method for use with the wide, short belts so often necessary in that class of machinery. Another, and better-known, instance is the slippage so often observed in the driving-wheels of a locomotive-engine when the train is heavy and the track wet.

The difficulty with all such actions lies in the fact that, in the engagement of the driving parts, the control of the gradual increase of motion, upon which the smoothness of action depends, has not that degree of certainty which enables the element of human judgment to be entirely omitted. The perfect clutch should, so to speak, "weigh its load," and so give automatically just such proportion of time to the engagement that the shock upon all parts of the transmission to which it belongs may be that which has been predetermined by its designer, regardless of the variations in its load, or of the suddenness with which it is thrown into gear.

THE increasing use of photography in all branches of engineering is well-enough known to need but little comment, but it is worthy of remark that it has not been given the same opportunity in mechanical engineering as it has in some other branches of the art of directing the forces of nature for the use and convenience of man. In civil engineering, in architecture, and indeed in all the outdoor branches of work, photography has been freely used, while in mechanical engineering it has been mainly used to make pictures of machines for the subsequent "promotion and publicity" of the business interests of the manufacturers. This latter branch of work is indeed most laudable and necessary, but it is not of this department of "engineering" that we desire now to speak. In nearly every large machine-shop, and indeed in most small ones, the blue-print process is now used for reproducing drawings, and hence the originals are in the form of tracings. Such tracings, being made quite clear and black, may be readily copied in the camera, and it is surprising to see how much reduction they will stand while yet retaining their full clearness and legibility. Drawings made upon "Double Elephant" size sheets, if made so as to give good blue-prints, can readily be reduced on a 6½" × 8½" negative, the tracing being placed in the printing-frame with a sheet of white paper behind it, care only being taken to avoid reflections of light in the glass which covers it. Blue-prints from such negatives are, for many purposes, as good as the original drawings, and have many uses for which the originals would be ill adapted. A set of such prints enables the engineer to carry important data with him away from the shop, and a full set stored away in a small safe-deposit box in a bank-vault is a provision against loss of important designs by fire, only attainable otherwise at much greater cost.

Another most important use of photography is in procuring accurate and hasty records of work in various stages of completion, temporary devices, experimental combinations, etc., and a home-made photograph of some early form is sometimes most welcome evidence in many an important patent suit. Such photographs may be made when time or ability to produce a sketch is not possibly available, besides which the photograph leaves nothing out; nor, unless tampered with, does it put anything in. Sometimes, indeed, it produces quite different evidence than was intended or desired by those using it. In one instance which has come to the writer's knowledge, a photograph was put in evidence as fixing positively the date of a certain construction as far back as the Centennial Exhibition. The point in question was the presence or absence of a certain set-screw, and the photograph, which was one of an exhibit at the Centennial, was produced to prove the absence of the set-screw. Apparently there was none visible, but an expert photographer thought he saw something in an otherwise black shadow, and the original negative was hunted up and an enlarged transparency of the portion in question made, when the set-screw, the absence of which had been positively asserted on the witness stand, was most plainly visible in the very photograph which had been introduced to prove its absence.

Photographs of test-pieces may be made useful to show details which would be most difficult to describe by words only, but here the greatest care must be used to avoid introducing errors of distortion. It has been truly said that photography cannot lie, but it is no less true that it can be "persuaded" to an extent which to the uninitiated seems hardly credible. Those who have seen at photographic exhibitions prints representing the same individual seated at a table playing chess with himself and with himself also looking on, or a headless individual calmly carrying his own head in a tray, can readily understand how methods similar to those employed in the production of such work might also be used in many far more deceptive ways upon mechanical subjects. Such work, however, is quite capable of being detected by those who are expert in photographic tricks, and need deter no one from making this most valuable art as serviceable in the details of mechanical engineering as it has already been made; in architecture for instance, and the above hints, which may be old to some, may yet suggest other applications not yet in use.

THE question of the value of labor-saving machinery depends somewhat upon the point of view of the individual, but if that individual be assumed to be the manufacturer, and not the laborer whose work is "saved," the value is often capable of being most positively demonstrated. Probably a traveling crane is more properly termed a "labor-saving" machine than almost any other, as it replaces the service mainly of what is termed the "laboring" gang. The introduction of electric power for operating such cranes has extended their use so as to include much yard work where it would formerly have been at least inconvenient to transmit power by other methods, and such cranes have proved themselves to be labor-saving machines indeed. In one instance it has been practically demonstrated that the entire cost of a most extensive system of electric traveling cranes for yard use was more than entirely met by the economy in labor attained in the first year of their use. It is not often that such data can be accurately obtained, as new devices are generally intended to perform work which previously had not been performed at all; no basis for comparison being available, but when, as in the above instance, human labor is replaced by mechanical devices for performing practically the same work, it is possible to obtain reliable data free from disturbing conditions. This example clearly proves what has already been asserted without such conclusive proof, *i. e.*, that in America at least human muscle is too expensive to compete with mechanical power.

This is hardly the place to discuss the subject from the standpoint of the laborer, but it may not be amiss to remark that the employment given to the workmen engaged in building the cranes is a new field of labor which would otherwise not have existed, and also that any devices which tend to abolish the use of men for purely animal work while also creating employment in a much higher grade of service, must ultimately tend to the advantage of the workman, whatever may be the immediate hardship wrought to those who are displaced at the time when the machines are introduced.

THE commercial value of London fog has been brought to notice in a rather curious manner by a remark made at a recent meeting of the Institution of Mechanical Engineers, by Sir Frederick Bramwell, to the effect that the unusual amount of sunshine during the past year had had a most depressing effect upon the dividends of the electric-lighting companies. While this has doubtless been the case, nothing was said about the increase in the dividends of the concerns which had been relieved from the expense of electric-lighting in the day-time, and surely the loss of the lighting companies must have been the gain of the users, whose point of view should hardly be ignored.

THE death of the late Reinhard Mannesmann, Sr., of Remschied, Germany, removes a man at once notable for his own work and also as the representative of one of the oldest and most important industrial establishments of Germany. In the United States the name of Mannesmann is perhaps best known in connection with the seamless rolled tubing, the machines for producing which were invented by Mr. Mannesmann and his sons; and the writer well remembers the interest with which the members of the American Society of Mechanical Engineers listened to the first description, by the late George H. Babcock, of this beautiful and valuable process. As Mr. Babcock neatly expressed it, in closing his remarks, "they take a hole, and roll a tube around it." But this process was but one, and indeed one of the more recent of Mr. Mannesmann's achievements, his most important work being in connection with the development of the steel industry in Germany.

Born in 1814, and naturally destined to enter the works established and conducted by his grandfather and father at Remschied since 1797, Reinhard Mannesmann did much more than merely conduct the industry on in the course of its natural growth. In many ways he showed himself in advance of the times, rapidly as the times themselves advanced; and in some instances he was so far in advance as to be obliged to wait awhile until the times had in some measure caught up with him. This was notably the case with the Chenot "direct process," which he undertook to establish in 1855, and in connection with which he was probably one of the first to suggest the electromagnetic separation of ores, a method which is now, forty years later, being pushed in more than one direction, in connection with the present state of the science of electromagnetism. Following this advanced attempt to develop the direct process, Mr. Mannesmann and his eldest son proceeded to make an exhaustive study of the molecular action which occurs in the production of crucible steel, with the result of developing the crucible-steel plant which became the successful rival of Sheffield, and carried away laurels at Munich, Paris, and, last year, at Chicago.

With all this industrial and scientific work came also opportunities, which were not lost, to take active part in the furtherance of the solution of social and economical problems. His relations with his men, his town, his country, and his sovereign were such as to make him noted had he accomplished nothing more; while among scientific men of every nation he held those close and cordial relations which more and more seem to indicate that it is through just such men as Reinhard Mannesmann that we may yet hopefully look forward to the realization of "the parliament of man, the federation of the world."

THE intimate relations which exist between the work of the electrical engineer and the mechanical engineer have been well brought out in the discussion which recently occurred upon a paper on the cost of electric energy, before the British Institution of Electrical Engineers. The questions of cost naturally involved the problem of the generation and utilization of steam and the subject drew forth the usual contentions about shell boilers against tubulous boilers; short-stroke high-speed engines against longer strokes and slower rotative speeds; jacketing and superheating, etc. Professor Unwin spoke most wisely when he said that "it was a matter for consideration in each particular case which method should be adopted," although he himself appeared to think that the best results were to be obtained by the use of long-stroke high-speed engines, with superheated steam to meet the question of cylinder condensation. Professor Unwin spoke in superlative terms of the practice of steam-engineering in Alsace, and called it the "best school of steam-engineering in the world," and the experience of forty years in the use of superheating under the conditions there common showed an economy from that source of at least 20 per cent., without any of the supposed ill effects upon the cylinders or valves. Another point in the same discussion, which bore also upon the domain of the mechanical engineer, was the question of the relative efficiencies of various methods of power-transmission, and Professor Kennedy said he looked forward with much interest to the tests of rope- and belt-driving about to be made in Belgium. These tests, to which reference has already been made in this Department, should certainly add much to our working knowledge of subjects which are at present almost entirely treated by empirical methods, and as Professor Kennedy truly remarked "there is very little exact knowledge available as to the power wasted by different means of transmission." In the present state of the development of electrical energy, it is to the skillful installation of the mechanical portions of the plant that commercial economies are mainly to be attained, and these relate almost entirely to the problems involved in the generation and transmission of the motive power.

THE ingenious idea of obtaining an unlimited supply of heat for the generation of power by boring a deep hole and so tapping the central heat of the earth, assuming the correctness of the theory of the existence of a central heat, has recently had some additional data furnished upon which to base further calculations. The deep-bore hole at Wheeling, W. Va., shows a temperature of 135° F. at a depth of 5000 feet, the increase in temperature during the lower part of the bore being about one degree for every 75 feet of depth. This was a more rapid increase than appeared at less depths, but assuming this rate to be uniformly continued it would require a depth of about three-and-a-half miles to obtain a temperature equal to that of steam at 100 pounds pressure. Just what results might be obtained in volcanic countries does not appear, but surely in such regions steam ought to be produceable by natural sources of heat much nearer the surface. After setting Niagara at work it may be next in order to impress into service either the geysers of the Yellowstone or even Vesuvius himself, and long before the available coal-supply is exhausted we may be drawing from natural sources of energy beside which the already paling brilliancy of natural gas shall be as the flickering tallow candle of past days.

IT is not always easy to estimate the value or extent of the influence of tradition in matters of mechanical research. Many things appear to be so because we have become so accustomed to taking them for granted that we do not consider them necessary subjects for investigation, and in further researches we are very often apt to extend matters which are true within certain limits to points far beyond those to which they are useful or even correct. This influence of tradition is far more powerful in connection with work along already-existing lines of thought, as is well shown by the reluctance of older engineers to take up the practical study, for instance, of electricity, or of any similar subject in which they feel the uncertainty of their established notions of the relations of cause and effects. For example, the manner in which the action of gravity might be influenced by local magnetic attraction might lead an otherwise well-trained mind, ignorant of the action of magnetism, to reject observations and deductions which failed to accord with earlier traditional ideas. A mind untrammeled by such tradition might seek for phenomena which would explain the otherwise mysterious action and so be led on to discoveries only awaiting such an investigator, and it is to just such minds that the solutions of the present mechanical problems will reveal themselves. The light of past experience is our most valuable guide in all things, but it must be directed forward, not backward, showing us "what to do, and how to do it, rather than what has been done and who did it."

COMMENT & CRITICISM

Air-Ships and the Motion of Birds.

SOME remarks on aërial navigation in the Mechanical Engineering department of the Magazine for May suggest some thoughts which I should like to see in print. It seems to me that most of our experimenters on air-ships and methods of supporting loads in the air are too close imitators of nature; that is, they strive to get their mechanical motions to act too nearly in the manner that a bird's wings seem to them to act, losing sight of the fact that a bird's pinions are capable of being distorted, and are distorted, during flight.

Our regulation animal painter has always produced pictures of horses running, showing beautifully-curved limbs, and we would not accept anything else. It was left to our friends, the Japanese, to picture the running horse with perfectly straight limbs, such as we would find under a sawbuck, were we so unfortunate as to be familiar with the latter domestic animal.

It has been left for the camera to show that the straight limbs were the correct delineation, some recent photographs of a race showing some famous horses running with legs perfectly straight, and the whole animal appearing to be balanced on the two fore-legs. The camera has indeed done much to dispel our false notions regarding the grace of moving animals, where the motion is too great for individual periods to be appreciated by the eye, for it shows that a bird in flying keeps its head constantly in motion, extending and contracting the neck, maneuvering the tail, and almost producing a rotary motion of the wings in order to change its course, the latter being as near a rotary motion as can be attained by bone and sinew.

If the bird could get a rotary motion with its wing, we should find what would approach as near to the propeller as feathers would admit of.

We might continue our argument with reference to the race-horse. Its speed limit probably will be reached ere long, when he who would produce a swifter one must breed a horse whose legs do not have a reciprocating motion but a rotary one; in short, bring the joints of the legs to a common center and revolve them, when they would become the spokes of a wheel and the appearance would be that of a locomotive with a single pair of drivers, about midway the animal.

My similes of course take much of the poetry and grace from the movements of our beautiful animals, but show, to my way of thinking, that in order to attain high rates of speed one must give up the reciprocating and adopt the rotary motion, and if ever aërial navigation becomes a success, as it must be at a high rate of speed, it leaves but the propeller to work with, which must leave very many of the workers in this line on the wrong track entirely.

But flying is not as much of a necessity as it was before the telephone came into use, and it will be still less a necessity when the telautograph comes into general use, for when we can communicate with and make a sketch for a man in a few minutes, or even seconds, with the width of the country between us, what need have we to fly to him? As to the success of air-ships, we must resort to that well-worn expression, "It is possible but not probable."

SAM. H. LIBBY.

Schenectady, N. Y., May 15, 1894.

Western Sympathy for Coxey.

IT is hardly possible for any one living in the east, who has not lately traveled westward or who does not read certain western newspapers, to appreciate the feeling about political and economic matters that prevails widely in the west. By this term is not meant the west of a few years ago, but what was then "the far west" and is now the newer west, to which Chicago seems to be an eastern city. I refer especially to the states of Iowa, Kansas, Nebraska, Colorado (and all the other silver-mining states), and in less degree to the Pacific-coast states.

Perhaps it will not be credited by eastern and foreign readers of THE ENGINEERING MAGAZINE that here the Coxey idea is regarded in quite a serious light by very many. If I say that it is looked upon as "a protest" against an intangible but sincerely believed-in wrong which can be righted by legislation, possibly my meaning will be understood. Hard times always have the effect of making some people believe that government should and could do something. Each always has some political panacea for commercial and industrial ills; though, taken in mass, the ideas are rather mixed. Hence the "greenback," the "granger," the "populist," the "fiat-money," and the whole host of visionary ideas, mostly of the paternalistic order. Here we are repeating the experience of the two or three years following the panic of 1873. In the west, as elsewhere, people feel the stagnation in business, the scarcity of work, and low prices for their products, and seek for a cause and a remedy. Many of them think they find the one in the oppression of employers, of corporations, of capital (which is always spoken of as "the money power"); the other, in an act of congress. They forget that if anybody has suffered in the general depression it is those who have most at stake, and they become bitter. The Coxey crusade, however absurd, is only one mode of expressing this feeling; but lately it happens to have been the most prominent. Why, you ask, should it be especially favored in the west?

It must not be supposed that the class referred to is made up altogether or mostly of very ignorant persons. On the contrary, the school facilities and the general grade of intelligence are as high in the west as elsewhere, and there is less of the ultra-ignorant foreign element that is found in the large eastern cities. But the education is that of the common schools and of the multitude of so-called "universities." It is that which leads people to think, and often to think very crudely. I do not in the least uphold the saying that "a little knowledge is a dangerous thing"; but it sometimes tends to create a misplaced reliance on judgment concerning matters that require a special study. The strength and safety of the country are in the average intelligence and education of its voters, and their common-sense brings them out all right in the end. One after another these queer crazes have their day, then die out. But meanwhile the habit of talking politics and economics—a good thing in itself—leads temporarily to some erratic results, which in time cure themselves.

Very many people, who admit that the Coxey army is head crank and tail tramp, encouraged it because of a vague notion that it might lead to something, somehow, though it cannot be said that they have any faith in Coxey's two cure-all bills. Their feeling is not merely the natural human sympathy with those in distress, of whom there are unquestionably large numbers, not counting cranks and tramps. It goes very much farther, but in no very definite direction.

The causes for this sentiment are various. In the western agricultural states the farmers have mortgaged themselves up to their eyes, and want Uncle Sam to pull them out. In the silver-mining states the decadence and in part extinction of a great industry has worked hardship, and those who suffer think that the monetary legislation of last year and the whole national financial policy are unjust and oppressive. The ordinary man of sense and education has his own point of view; only the philosopher can look at things from various sides. But how many philosophers are there? F. C. CHASE.

In the Far West, June, 1894.

The Mining District of Ecuador.

IN the Magazine for May Mr. Arthur L. Pearse, in an article on gold-mining in South America, has this to say regarding Ecuador;

There is a great field for prospectors here, and doubtless a great deal of mineral wealth, but the difficulty of coping with the tropical vegetation and with the Indians, one of the tribes, the Yibarra, being cannibals, renders the development very slow.

I have recently returned to the United States from Ecuador, where I was engaged in the preliminary survey and examination necessary to start the plant for placer gold-mining on the property of the Cachari Company. This property is located on the Cachari river, a tributary to the magnificient Rio Santiago, about thirty to thirty-five miles from the Pacific coast, and about eleven miles on a straight line north of the Playa d'Oro Mining Co.'s property, near the frontier of Colombia, and right in the gold-mining part of Ecuador.*

I was in Ecuador about four months, surveying and exploring every day. Now as to the vegetation, it is tropical and of course rather heavy in places, but not so bad but that my party, with from four to six axemen, could run from 3000 to 4000 feet transit and level line every day, cutting a path through the forest ten to twelve feet wide, large enough for ditches and pipe-lines, and that in spite of several hours' heavy rain daily. The old Spanish planters have—in a primitive way—mined gold there for at least 150 years back, the proof of which was found in the many ditches and several reservoirs I ran across in my survey. These ditches, 8 to 10 feet deep and 2 to 5 feet wide, and some with almost vertical slopes, were even now free of vegetable obstructions, and in such a state of preservation, that the Cachari Co. intend to utilize several of them in the construction of their mining plant, which is now going on. The Playa d'Oro Co. are also constructing miles of ditches and pipe-lines without encountering any difficulties from vegetation. The chief obstacle to placer mining in Ecuador, at least where I was, is found rather in the formation of the country, which consists of numerous very irregular valleys, ridges, and "lomas," running in all directions, caused by the equally numerous creeks and rivers, which of course in places again necessitate longer and more expensive ditches and pipe-lines.

As to the "cannibalistic Indians," every one who went to Ecuador with me, as well as I myself, returned "all whole." In the part where I was, which at present is the real mining district of Ecuador, I "heard stories" about tribes of wild Indians still existing in the far interior, east of the Cordilleras or Andes mountains. This vast territory is very wild, entirely uncultivated or explored, and supposed to be inhabited only by these Indians, who may even now, during "hard times" roast a fellow-being for "a square meal." If there is any mining to be done there, it is at present an impossibility simply for lack of means of communication.

One of "the stories" I heard told how these Indians, in the beginning of the century, raided a prosperous city of 20,000 inhabitants on the eastern slope of the Andes, killed all the males and children, and carried off the women as their unwilling "better halves." It is supposed now that the influence of this "white blood" has since made their descendants more gentle and tame. The fact is, that the Indians I saw,—and I had several of them from the interior in my party,—were "rather tame," living mostly on rice, beans, and plantains. They were very ugly and decidedly dirty and primitive in their manners and dress, but they gave us no fear on account of cannibalism.

OSCAR A. F. SAABYE, C. E.

New York, June 4, 1894.

The Obstacle in Peru.

In several articles—first and last—about Peru, I notice that contributors to the Magazine wonder why that country is not entered by Americans and "developed;" in fact, why nobody seems to take any interest in it, although it is in many parts an Eden and contains mineral wealth enough to satisfy the world. There is no mystery about it whatever. If you were plumped down in Lima by a balloon you would find out from your own observation in less than an hour what the reason is. Catholicism is the answer to the riddle. "Religion" is the supreme concern, and all business affairs are mere side-shows that may get along the best way they can, only they must keep out of the way of "religion." Of course the "religion" is not such as the people of the United States have been accustomed to call by that name. It is not Christianity any more than Buddhism is. It is the Power of the Church, but they call it "religion" to make it more endurable. Americans and Englishmen are called "protestants," and are at heart considered as dirt. Not to be a Catholic is to be on a par with the most degraded riff-raff of the world; and a non-Catholic is fair game for anybody who may care to dirty their fingers with him. A *protestante* is ostracized. Some cultivated and foreign-educated people may treat him decently and civilly, but they will not like him. The teachings of the *padres* that have been ground in the inmost fibers of the Peruvian's nature will assert themselves more or less as long as life lasts. So you see that a foreigner is surrounded by enemies, as it were, and he can never count on the pretended friendship of his acquaintances. All the clap-trap of spectacular religion is forever going on, and the weekly occurrence of "feast-day" prevents one from carrying on a regular business like manufacturing. The workmen *dare* not work on "feast-days," and what with the interference of masses and vespers, and angelus, and matins, and what-not, a foreigner gives up the game disgusted and quits. Only natives can stand the racket. This ostracism on account of religious belief—aside from the intolerable bother the church requirements produce—is the big factor. It never lets up. You are never allowed to forget it, and it works against you all day, and even when you are asleep at night. So long as Peru is without the blessing of religious freedom all the talk about gold and india-rubber and other products down there will come to naught, as sure as the sun shines. N. J. S.

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* See article by Russell F. Lord, C. E., in The Engineering Magazine for May, 1892.

Frankfort, Ky., June 4, 1894.

The History of Portland Cement.

IN Professor Newberry's article on cement, in the June issue of the Magazine, we notice that he says that the manufacture of Portland cement was begun in the United States at Coplay, Pa., in the year 1878. This is an error, as the Coplay Cement Co., at Coplay, Pa., started the manufacture of "Saylor's Portland cement" in 1872, but were not entirely successful until the beginning of 1875. From this time on, they have made an excellent Portland cement. General Gilmore, on December 19, 1876, writes as follows: "I found 'Saylor's Portland cement' on exhibition in the International Exhibition at Philadelphia. There were fourteen Portland cements exhibited, all of which were tested under my direction. 'Saylor's' cement stood among the five best specimens." WILLIAM G. HARTRANFT.

Vice-president Commercial Wood and Cement Co.
Philadelphia, June 9, 1894.

Captions That Went Astray.

IN printing the June Magazine, there was an unfortunate transposition of the captions of two pictures accompanying Mr. David L. Barnes's carefully-prepared paper on "The Future and Present Locomotive." As printed they read—

Fig. 9—Mountain climber, dacapod type;
Fig. 12.—High-speed passenger locomotive "Flying Dutchman" type—

but in each case the cut which appeared should have been used over the other caption. The engraving which appeared on page 404 as "Figure 10" was one not intended to be used in the Magazine, while the proper cut did not appear at all.

CURRENT TECHNICAL LITERATURE

PROGRESS IN FLYING-MACHINES. BY OCTAVE CHANUTE, C. E. New York : *American Engineer and Railroad Journal.* [Cloth 8vo. vi-308 p. $2.50.]

AERIAL NAVIGATION. BY J. G. W. FIJNJE VAN SALVERDA, late Administrator of Public Works of the Netherlands, and Advisory Councillor for Hydrotechnic and Railway Affairs. Translated from the Dutch by George E. Waring, Jr., with notes concerning some recent development in the art. New York: D. Appleton & Co. [Cloth. 12mo. vi–209 p. $1.25.]

THE change which has come over methods of invention and which has almost relegated to the past the visionary inventor is nowhere so distinctly indicated as in the modern treatment of the subject of flying-machines. Not so very many years ago any man who allowed it to be known that he was devoting any of his time to the invention of a flying-machine ran great risk of finding himself considered a candidate for an insane hospital, but here we have a well-known and highly-esteemed past-president of the American Society of Civil Engineers venturing to appear as the author of a treatise upon this subject; while at the same time another well-known American engineer gives to the public a translation of the work of one of the most distinguished engineers of Holland upon the same branch of mechanical science.

Mr. Chanute's book is largely historical in character, and as such is most interesting. He dismisses at the outset the subject of balloons as having been treated already in his previous work on aërial navigation, and proceeds to discuss, practically in chronological order, the various plans which have been suggested for attaining success in aërial flight by strictly mechanical means. These he classifies into three main divisions: wings and parachutes, screws to lift and propel, and aëroplanes. The first group is the natural result of a number of more or less imperfect observations of the flight of birds. It is not surprising that the imperfect nature of these observations should have led to many blunders. Nearly all the early experimenters assumed that the flight of birds was accomplished by the flapping action of their wings alone, and from the time of Leonardo da Vinci down to the present day a long series of wing devices, intended to enable man to imitate this supposed action of the bird, shows the persistence with which a mistaken idea will cling to the mind of man.

Rebelling against this succession of failures, and doubtless influenced also by the action of windmills, spiral toys, and similar devices, the mechanics of more recent days have expended much thought upon the construction of machines the action of which was based upon the principle of the screw propeller, and these form the subject of Mr. Chanute's second division. The twirling propeller toy is doubtless known to almost every one, but it carries no part of the weight of the motor to which it owes its action, and, even when actuated by twisted rubber springs or other simple form of power storage, it has yet to be shown that this system carries within it the promise of success. When it is considered that Giffard's experiments showed that the direct-lifting action of screws, unaided by any combination with aëroplanes, was only about 27 pounds per horse-power, it will be seen that a motor of 27 pounds weight per horse-power would just be able to lift itself; hence, until much lighter motors than are at present known are introduced, there is little to be expected in this direction.

By far the most interesting branch of the subject is that which includes the so-called "aëroplanes," and the greater portion of the works of both Mr. Chanute and M. van Salverda is given to this, the most promising field of recent investigation and experiment. The aëroplane is really the direct outcome of more accurate and intelligent observations of the flight of birds, and especially of the difference between "soaring" and "flapping" flight; and the differences which appear in the action of various kinds of birds when studied in the light of modern methods of investigation and with the aid of instantaneous photography have led to most valuable results. The difference between this form and that just referred to, is shown by the fact that Professor S. P. Langley's experiments have demonstrated that a screw which could scarcely lift 30 pounds by its direct action can, in combination with an aëroplane, lift as much as 200 pounds. Mr. Maxim's experiments, conducted with all the care due to the ability of such a practical investigator, have practically demonstrated that a lifting capacity of at least 133 pounds per horse-power can be obtained, and it is well known that several modern torpedo-boats are equipped with motors weighing not more than 60 pounds per horse-power.

An aëroplane is really little more than a kite in which the string, the pull upon which holds it to its correct angle to the wind, is replaced by the motor. When, as in the case of Herr Lilienthal's machine, there is no motor, the horizontal component of the weight of the aëronaut is so directed as to keep the angle of the aëroplane at the desired pitch, and the really remarkable results which the latter gentleman has obtained bid fair to develop into most definite form. These cannot be more than hinted at in these pages, and we must refer those who are interested to the volumes themselves, and indeed both books should be in the library of every one who is at all interested in this subject.

To all who desire to study the present status of the problem in the light of what has been done in the past, Mr. Chanute's work is especially valuable, containing, as it does, historical data of wide extent, gathered from sources which in many instances are not readily accessible, and its thorough perusal may enable many an investigator to avoid errors into which he would have fallen but for the record of these experiences and failures of the past.

The book of M. van Salverda is in some respects more popular in its character, but none the less scientific in its treatment of the subject on that account. Besides the original work of the author, as written in 1892, it contains copious extracts from a later pamphlet, written by him in the light of the experiments of Langley, Maxim, and Holland, and the translator has added a most valuable appendix giving in abstract the substance of Langley's "Experiments in Aërodynamics," Holland's essay on "Mechanical Flight," and Langley's later and very important paper on "The Internal Work of the Wind," thus placing the very latest information upon the subject in a shape for intelligent and comparative study.

HENRY HARRISON SUPLEE.

HYDRAULIC POWER AND HYDRAULIC MACHINERY. By Henry Robinson, M. Inst. C. E., Professor of Civil Engineering, Kings College, London. Second Edition. With numerous Woodcuts and Plates. London: Charles Griffin & Co., Limited. Philadelphia: J. B. Lippincott Co. [Cloth. 8vo. xvi–226 p.]

FROM the title of this book and that of its author one would be led to suppose that it was intended either as a text-book or as a work of reference on hydraulics, including hydraulic machinery. One is still further led to believe this from the opening chapters. The first chapter, occupying nine pages, is devoted to the discussion by means of simple mathematics of the discharge through orifices. This discussion, while extremely elementary, is exceedingly good as far as it goes, but falls far short of the requirements of even an elementary text-book. The second head —gaging water by weirs—is still less comprehensive, occupying but three pages. It is so short, however, that it scarely deserves the title of chapter, nor does the author give it this name. This is followed by a chapter on flow of water through pipes. Although twelve pages are devoted to this subject its treatment is very superficial and incomplete. The most valuable portion of this chapter is the discussion of the "critical velocity" of flow as investigated by Professor Osborne Reynolds, which is defined as that velocity at which, in a given pipe, the water, instead of following parallel lines, suddenly bursts into eddies. In the equation for velocity $v = \frac{R^4}{C^n \sqrt{S}} \times (1 + \frac{T-50}{K})$ and that for discharge in cubic feet per second— $Q = \frac{D^2 + {}^4}{P^n \sqrt{S}} \times (1 + \frac{T-50}{600})$ it is stated that below the critical velocity *n* may usually be taken as 1 while at the critical velocity it suddenly jumps to about 4. Several diagrams are given to show how this great change may be explained, and other results of Professor Reynolds' experiments are given without such qualifications as would be necessary in a book such as we are supposing this to be thus far. Three large plates intending to show by reference (1) the flow of water in smooth pipes (lead, tin, copper, etc.), (2) the flow of water in iron pipes, and (3) the flow of water in brick culverts, accompany this chapter. The curves in these plates are plotted from equations given on each and are intended as labor-saving devices for the determination of results under similar conditions without resort to calculation. Every one appreciates the value of diagrams of this kind when they are reliable, but these particular diagrams are rendered almost entirely useless by the meagerness of the instructions as to how to interpret them. These three introductory chapters are by far the most meritorious in the book and yet there is scarcely a manufacturer of turbine- or other water-wheels in this country who does not include in his catalogue fuller information on all of these subjects, arranged in better shape for use by the practical man than is contained in these pages.

The remainder of the book is taken up by descriptions of individual hydraulic machines or installations—the characters of which will be sufficiently indicated by the following titles, "cyclone hydraulic baling press," "anderton hydraulic lift," "the Otis elevator," "North Hudson County railway elevator," "Pearsall's hydraulic engine," "hydraulic ram," "Tweddell's hydraulic rivetter," etc. Many of these are well illustrated with copper-plate engravings, but in most cases the descriptive matter is so inadequate and trivial as to be valueless to the student and to the engineer alike. An illustration of this is the treatment of the Greathead shield and method of operation. This subject might well take up a volume by itself, but is here dismissed in two pages, which include a woodcut, and a large copper-plate in addition. The result is that no one who did not before know something about the Greathead system could gain from this chapter any clear idea of what it is, and to him who did know something about it the chapter would be utterly useless.

In conclusion, it is difficult to classify this book. It is a curious medley or pot-pourri of odds and ends thrown together apparently without judgment or purpose. It is *not* a trade catalogue, though it partakes somewhat of the nature of one without having the value to the engineer that many American trade catalogues have. It is in no sense a text-book, nor could it by any stretch of the imagination be thought of as a work of reference. It is a fairly good specimen of the bookmaker's art, but reflects no credit either upon the author or upon the judgment of the publishers, and we can scarcely conceive how it could have come into a second edition.

NELSON W. PERRY.

A MANUAL OF PRACTICAL ASSAYING. BY H. V. F. FURMAN, E. M. First edition (second edition in press). Illustrated. New York: Wiley & Sons. [Cloth. 8vo. vi–390 p. $3.]

IT is not often that current practice in assaying,—that is, the practice of the great metallurgical works and the commercial laboratories, not that of the schools,—is described so that students and assayers who have not had this experience may profit by it. A busy assayer may occasionally find or make time to bring before the profession some new wrinkle that he has hit upon, but information of this kind is scattered and incomplete, and of only partial value to one who needs a general exposition in available form. Mr. Furman has done a most valuable service in preparing the present volume, which is (within its scope) the best work on practical assaying yet issued. It is not merely a book for students, but one which would be of assistance to almost any working assayer. There is a great deal of matter in most chemical text-books about which the student is left in some uncertainty,—for instance, where a choice of methods is presented and no guidance given. Mr. Furman is always very decided in stating the reasons for his preference for one method or style of apparatus rather than another, and is very clear in describing manipulations. The rapid methods in vogue in the technical laboratories of this country are given especial prominence, while some of the longer and more exact ones (such as are usually taught in the schools and then discarded when the assayer gets into practice) are also given in detail. There is a great deal that is generally taught—and that ought to be taught, in order to inculcate precision and present a wide range of methods—that has to be supplanted by more direct methods. At a mill or smelter, where the samples come in upon the assayer by the dozen and the reports are expected at a certain hour, it is necessary to adopt new systems and half learn the business over again. The trick of handling large numbers of assays quickly, quietly, and systematically, without becoming rattled, is the essential point. Rapid work does not mean slovenly work, but a judicious economizing of time and effort. It is in this direction that this "Manual of Practical Assaying" constantly points.

A. W., JR.

MINE VENTILATION MADE EASY, WITH AN APPENDIX. Containing Answers to 155 Questions Selected from Various American Examinations for Mine-Inspectors and Mine-Foremen. By William Fairley, Ph. D., F. G. S., M. E. Scranton, Pa.: The Colliery Engineer Co. [Cloth. 12mo. 110 p.]

THIS is a carefully-prepared, concise work for the use of mine-officials and mining students. It is written in simple language and clears away many of the seeming difficulties attending this rather complicated branch of colliery engineering, often regarded as the great stumbling-block in the way of the student, and the mathematical side of which is often approached with diffidence. Mr. Fairley has made a very thorough treatise on the subject, which will be appreciated by those who have occasion to study or consult it. The work has already appeared as a serial in *The Colliery Engineer*. Students and miners who are preparing themselves for examination as mine-inspectors or foremen will find the selected questions and answers given in the appendix valuable as a "coach," as they indicate the points to which most prominence is given in such examinations.

A. W., JR.

THE INDUSTRIES OF RUSSIA. BY THE IMPERIAL MINISTRY. Editor of the English Translation, John Martin Crawford, United States Consul-General to Russia. Five Volumes. St. Petersburg: Published by the Government. New York: G. P. Putnam's Sons. [Paper. 8vo. liv-280 p.; ii-296 p.; xxxii-488 p.; x-98 p.; xii-265 p. $6.]

THE literature of the World's Columbian Exposition was richly enhanced by this series of volumes, due in its inception to the czar's idea that, however successful the choice of exhibits for the Fair might be, they could not alone convey an adequate idea of the productive forces of the empire and its industrial development. Hence the various branches of the imperial ministry undertook, with the aid of specialists, the preparation of a work which should be an authentic résumé of Russian technical progress up to date. The first two volumes review manufactures and trade; the third is devoted to agriculture and forestry; the fourth, to mining and metallurgy; and the fifth, to Siberia and the great Siberian railway. These reports are treatises or monographs, and not catalogues of exhibits. The editor of the English translation, Consul-General Crawford is thoroughly familiar, not only with the Russian language, but with many of the principal branches of industry.

DIRECTORY TO THE IRON AND STEEL WORKS OF THE United States, Canada, and Mexico. Twelfth Edition. Corrected to March 1, 1894. Philadelphia: American Iron and Steel Association (James M. Swank, General Manager, No. 261 South Fourth street). [Cloth. 8vo. xii-292 p. $5, or 20*s*.]

THIS very admirable and comprehensive work, covering the changes made in the development of the industries represented since the appearance of the preceding edition (February, 1892), leaves nothing to be desired by those for whose use it is intended. It is concisely gotten up, every page being devoted to the legitimate purposes of a directory, without any advertising features whatever. The book serves also as a convenient statistical summary, and its indexes guide one at once to any feature sought for. Altogether the work may be commended as an excellent model for the compilers of industrial directories generally. Orders may be sent to Mr. Swank, at the address given above.

NEW BOOKS OF THE MONTH.

American Institute of American Architects.=Proceedings of the Twenty-seventh Annual Convention, Chicago, August, 1893. (Including Proceedings of the World's Congress of Architects.) Alfred Stone, Editor. Chicago: *Inland Architect* Press. [Paper. 4to. 399 p.]

Burke, M. D.=Brick for Street Pavements. An Account of Tests Made of Bricks and Paving-Blocks. Second edition, with a paper on Country Roads. Cincinnati, Ohio: Robert Clarke & Co. [Paper. 8vo. 108 p. 50 cents.]

Luber, Oscar M.=The Assayer's Guide; Or practical directions to assayers, miners, and smelters, for the tests and assays, by heat and by wet processes of the ores of all the principal metals. New and enlarged edition. Illustrated. Philadelphia: H. Carey Baird & Co. [Cloth. 12mo. 283 p. $1.50.]

Means, James.=The Problem of Manflight. Showing what has been done In aërial machines and the probability of what may be done in the future. Illustrated. Boston: W. B Clark & Co. [Paper. 8vo. 20 p. 10 cents.]

Paterson, Howard.=The Navigator's Pocket-book, Arranged for Immediate Reference to any Navigation Subject. New York: Scribner. [Leather. 24mo. 6-177 p. $2, net.]

Patton, W. M.=Practical Treatise on Foundations. New York: Wiley & Sons. [Cloth. 8vo. $5.]

Rothwell, Richard P., *editor.*=The Mineral Industry, its Statistics, Technology, and Trade, in the United States and Other Countries, From the Earliest Times to the End of 1893. [Second annual Statistical Supplement to the *Engineering and Mining Journal.*] New York: Scientific Publishing Co. [Cloth. 8vo. xl-864 p. $5.]

Smithmeyer, John L.=The Competitive System in Government Architecture. A plea for better buildings and better laws, together with a history of the movement to secure them. 1873-94. Washington, D. C.: Gibson Brothers. [Paper. 8vo. 23 p.]

Smithsonian Institution.=Annual Report of the Board of Regents, Showing the Operations, Expenditures, and Condition to July, 1892. Washington: Government Printing Office. [Cloth. 8vo. 811 p. $1.]

Stokes, Anson Phelps.=Joint-Metallism: A Plan by which Gold and Silver Together, at Ratios Based on their Market Values, may be made the Basis of a Sound Currency. (Questions of the Day Series.) New York: Putnam. [Cloth. 12mo. 8-124 p. 75 cents.]

Traill, H. Duff=Social England. A record of the progress of the people in religion, laws, learning, arts, industry, commerce, science, literature and manners, from the earliest time to the present day, by various writers. Vol. I. New York: Putnam. [Cloth. 12mo. $3.50.]

Trevert, E.=Electrical Measurements for Amateurs. Illustrated. Lynn, Mass.: Bubier Publishing Co. [Cloth. 3-117 p. $1.]

United States=Twelfth Annual Report of the Geological Survey, 1890-91. By J. W. Powell, Director. Vol. I—Geology. Vol. II—Irrigation (including report by H. M. Wilson on Irrigation in India.) Washington: Government Printing Office. [Cloth. 8vo. xiii-675 p., 53 plates; xviii-576 p., 146 plates.]

Walker, Francis A.=Bimetallism. A tract for the times. Boston: Damrell & Upham. [Paper. 8vo. 24 p. 10 cents.]

Watson, E. P.=How to Run Engines and Boilers. Second edition Illustrated. New York: Spon & Chamberlain. [Cloth. 12mo. 115 p. $1.]

Williamson, Benjamin.=Introduction to the Mathematical Theory of the Stress and Strain of Elastic Solids. New York: Longmans, Green & Co. [Cloth. 12mo. 7-135 p. $1.50.]

Williams, G. H., *and* Clark, W. B.=Outline of the geology and physical features of Maryland, with a geological map of the State. Baltimore: Johns Hopkins Press. [Paper. 8vo 8—67 p, maps. $1]

Worthington, T. Locke.=The Dwellings of the Poor and Weekly Wage-earners in and Around Town. With an Introduction by G. V. Poore, M. D. New York: Scribner's. [Cloth. 12mo. $1.]

Wyatt, Francis.=The Phosphates of America. How they occur, how they are mined, and what they cost. With practical treatise on the manufacture of sulphuric acid, acid phosphate, phosphonic acid and concentrated superphosphates. Fifth Edition. Illustrated. New York: Scientific Publishing Co. [Cloth. 12mo. $4.]

NEW TRADE CATALOGUES.

Any of these catalogues free on application to the manufacturers.

McGrath & Collins, Cohoes, N. Y.=Emery Grinders, Polishing and Buffing Machinery for all Metals. 24 p.

The Perfection Sash Balance Company, Rochester, N. Y.=Illustrated Price List. 32 p. [Spring sash-balances, elevator-gates and doors, show cases, etc.]

The Sebastian-May Company, Sidney, Ohio. =Foot Lathes and Engine Lathes. Emery Grinders, Planers, Shapers, Chucks, etc. 16 p.

American Railway Maintenance Syndicate, Philadelphia.=The Columbian Metallic Railway Ties. 16 p.

The St. Louis Well Machine and Tool Company, St. Louis.=Well Machinery, Tools, and Supplies for Sinking Wells of All Kinds. 48 p.

Roberts, Thrap & Co., Three Rivers, Mich.=The "Cyrus Roberts" Patented Hand Cars. 16 p. [Suspended light hand car wheel; improved standard hand car, etc.]

M. Beatty & Sons, Welland, Ontario.=Steam Dredges, Ditchers, Derricks, and Shovels. Hoisting Engines, Centrifugal Pumps, etc. All Contractors' Supplies. 40 p.

The H. A. Williams Manufacturing Company, Boston.=Oilers, Lamps, and Brass Specialties. 28 p.

The Hart & Hegeman Manufacturing Company, Hartford, Conn.=Hart Switches and Flush Plates. 20 p.

THE

ENGINEERING MAGAZINE

VOL. VII. AUGUST, 1894. No. 5.

OUR ENORMOUS ANNUAL LOSS BY FIRE.

A WASTE BORN OF IGNORANCE AND NEGLECT.

By Edward Atkinson.

THE waste of property by fire is increasing year by year, in undue proportion to the increase of property at risk. Last year's ash-heap in the United States has been computed in excess of $150,000,000. In order to ascertain the true measure of the fire-tax we must add to this some $60,000,000 to $70,000,000 as the cost of sustaining insurance companies, by which a part of the loss is distributed throughout the community. To this again must be added the cost of sustaining fire-departments, which came to $25,000,000 some years ago, when I first investigated this subject. Thus the measure of this fire-tax in the past year cannot have been less than $250,000,000. That is the penalty which we pay for ignorance, stupidity, carelessness, and crime, for which the responsibility must be distributed mainly among owners of buildings, though shared in part by occupants, architects, and builders.

Is there no remedy except further destruction? That this ruin may be remedied has been made plain in many ways. That it may be remedied in large measure without the excessive cost of what is called "fire-proof construction" has been fully proved by long experience in building, and in protecting and saving from loss what have become known as the "slow-burning factories and workshops" in the eastern and middle United States. These slow-burning methods of construction have been widely extended of late throughout the west. Great changes have occurred lately in the sense of responsibility for loss by fire. Owners have become aware that the bad methods of combustible architecture are costly and wasteful, and that they are themselves in fault for their adoption. Many architects of repute have made plans

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and are prepared to meet the demand for slow-burning construction at moderate cost. Builders are being held to a sense of their responsibility to the end that they may no longer permit careless workmen to sweep shavings into the spaces of the hollow floors where they have heretofore been left, resting upon the ceilings of the rooms below. There is yet a vast deal of work to be done, especially in the education of real-estate owners. To that end the writer has again undertaken to treat this question in the light of his later experience.

It is not many years since I predicted the end of the system of "combustible architecture," as I then named the common practice of building, at which end we have about arrived. Insurance companies have gradually realized that betting that bad risks will not burn and paying high commissions for the sake of getting a small wager is a bad business. Many have failed; others have been wound up; the survivors are now taking the only safe and judicious course,—namely, writing risks only according to the measure of hazard, insisting upon adequate premiums (which in many instances are not yet high enough), enforcing frequent inspections, and refusing to insure any considerable amount in a great many sections of cities, especially upon some of the costly examples of combustible architecture which are still very numerous. This course of the underwriters brings the responsibility where it belongs: upon the owners of unsafe buildings, who, finding themselves unable to let their property because their tenants cannot procure insurance, are now trying to find the remedy which they might long ago have anticipated.

At one time the writer transferred to the pages of the *Century* magazine some of the data of the experience of the factory underwriters of New England, under the title of "Slow-Burning Construction." Strangely enough many men, themselves large owners or occupants of combustible warehouses in cities, held at the same time positions as directors or members in factory mutual insurance companies carrying risks on textile factories, paper-mills, machine-shops, and other similar works of a hazardous and sometimes of an extra-hazardous kind. In the conduct of these insurance companies they soon came to a very clear sense of the fire hazard. The main object of the work of the factory mutual underwriters is to prevent loss by fire; the secondary purpose being to pay indemnity for loss when it occurs. The underwriters hold the owner or manager of the factory to a strict account in explanation of the reason why any loss may have occurred, nearly all losses being traceable to some fault either in construction or on the part of the occupant. When that rule is applied to hospitals, asylums, churches, schoolhouses, and city warehouses and shops, they may be made fit to insure, and not before.

In the direction of this work it became apparent to the officers of these factory mutual insurance companies (1) that there is no such thing as a fireproof factory-building and (2) that if there were it would cost too much to construct it. In a great many buildings constructed in Europe for textile purposes, commonly known as "fireproof factories," the combustion of the contents has frequently occasioned complete destruction. They are merely buildings made of incombustible materials—usually brick and iron. Iron is one of the most treacherous of all building materials when suddenly exposed to a high heat.

In the course of a long period the slow-burning factory-building was evolved under the supervison of the underwriters, and the publication in the *Century* magazine of the principles of slow-burning construction exerted, throughout the country, a very powerful influence on industrial architecture. In many instances, however, these principles of construction were so little comprehended and were so perverted in practice that buildings which were ostensibly slow-burning were really liable to the most rapid destruction by fire.

The growing evil of our present fire-tax and the excessive loss to which reference has been made must be stopped. If it is not stopped soon, adequate insurance on any and all city warehouses will become impossible. The evil is not in the expense of conducting the insurance business, although under ordinary conditions that is a very heavy charge. The present trend toward what are called Lloyds associations and the organization of the mutual insurance companies for the purpose of giving contracts of indemnity on city buildings may end in yet greater disaster; it surely will so end if it puts off the only method of meeting the evil by improving the risks.

Reference has been made to the perversion of the slow-burning principle. I may venture to describe what it is and what it is not, after which I will proceed to deal with other elements in this case.

The system of mill-construction should be considered as a whole by an architect who undertakes to apply it; otherwise grave errors may be made. The very title which I have given it myself—"slow-burning construction"—would sufficiently indicate to any thoughtful person that mill-construction did not consist simply or wholly in laying floors or roofs of thick planks on heavy timbers, spaced widely apart. That is but one element in slow-burning or mill construction. It goes without saying that wide and exposed surfaces of wood, however disposed, may burn rapidly under almost any conditions, *if not suitably protected;* such buildings will surely burn rapidly if so finished as to promote the rapid spread of fire upon or under such wooden surfaces, without any provision for stopping such fires.

No advocate of mill-construction pretends that there are not examples of so-called fireproof construction which will burn more slowly, or which will be destroyed by fire more slowly, than any possible construction of wooden timber and plank. But, as I have said, the extra cost of this type of construction in many instances may be saved.

The motive of mill-construction is economy as well as safety. There are many classes of business that will not bear the heavy cost of a more strictly fireproof method of construction. Moreover, the factory of approved mill-construction has proved to be so safe as a whole, and such factories have been covered by mutual insurance at so little cost, as to render it wholly inexpedient or even unnecessary for the owners of textile factories and workshops to take any other method into consideration.

For instance, wherever the mill-floor, suitably constructed of three-inch plank, grooved and splined, covered with one-inch top boarding, laid on timbers eight or ten feet on centers, has been made continuous,—that is to say, without any break for belt-holes, open elevators, or open stairways,—it has never been burned through by a fire upon the floor or by fire passing through the floor above, except in one instance, and that was in a warehouse where a pile of jute bales took fire in a place where it could not be reached. The firemen then put water through the hole from open butts and drowned it out. Fires on such mill-floors have been held, not only in the building, but in the room where they originated.

Again, iron posts have been crippled or sprung by heat a great many times at an early period in a fire. A wooden post of suitable size has never burned off until other parts of the building were already destroyed. They have in one instance resisted for hours fire which destroyed granite posts near them by reducing them to sand—the granite measuring 12 by 12 inches. In this instance oak posts were put in between the original posts of granite to bear an added weight of machinery. When the fire came the oak sustained the whole load.

To repeat, the mill-floor properly constructed and rightly guarded has sufficed to hold fires, not only in the building but in the room in which they have originated, until the mill fire-department or the public fire-department could extinguish the fire. The wooden mill-post of suitable size will last longer than the floor. The mill-floor possesses this very great advantage over the ordinary joisted floor: Fires may be readily swept away between the timbers either by sprinklers or by water from hose-pipes; while in the joisted floor or floor laid over plank on edge, 18 inches to 24 inches apart on centers, the fire will burn on one side of the joist or plank while the water is playing on the other side.

Lest this mode of construction should be subjected to prejudice through ignorance, I will now state what mill-construction is and what it is not.

WHAT MILL-CONSTRUCTION IS.

I. Mill-construction consists in so disposing the timber and plank in heavy solid masses as to expose the smallest number of corners or ignitable projections to fire, to the end also that when fire occurs it may be most readily reached by water from sprinklers or hose.

II. It consists in separating every floor from every other floor by incombustible stops,—by automatic hatchways, by encasing stairways either in brick or other incombustible partitions,—to the end that a fire shall be retarded in passing from floor to floor to the utmost that is consistent with the use of wood or any material in construction that is not absolutely fireproof.

III. It consists in guarding the ceilings over all specially hazardous stock or processes with plastering laid on wire lath or upon dovetailed lath or by plaster board of a suitable kind, following the lines of the ceiling and of the timbers without any interspaces between the plastering and the wood ; or else in protecting ceilings over hazardous places with tin or other suitable metal, but not with zinc.

IV. It consists not only in so constructing the mill, workshop, or warehouse that fire shall pass as slowly as possible from one part of the building to another, but also in providing all suitable safeguards against fire.

V. It consists in laying the top floor and the outer boarding of the roof *over mortar*, plaster-board, or some other fire-retardent between it and the plank, where the maximum of safety is to be attained.

WHAT MILL-CONSTRUCTION IS NOT.

I. Mill-construction does *not* consist in disposing a given quantity of materials so that the whole interior of a building becomes a series of wooden cells ; being filled with concealed spaces, either directly connected each with the other or by cracks through which fire may freely pass where it cannot be reached by water. That is the common practice now named "combustible architecture."

II. It does *not* consist in an open-timber construction of floors and roof resembling mill-construction, but of light and insufficient size in timbers and thin planks, without fire-stops or fire-guards from floor to floor.

III. It does *not* consist in connecting floor with floor by combustible wooden stairways encased in wood.

IV. It does *not* consist in putting in very numerous divisions or partitions of light wood.

V. It does *not* consist in sheathing brick walls with wood, especially when the wood is set off from the wall by furring, even if there are stops behind the furring.

VI. It does *not* consist in permitting the use of varnish upon woodwork over which a fire will pass with the speed of a race-horse.

VII. It does *not* consist in leaving windows exposed to adjacent buildings unguarded by fire-shutters.

VIII. It does *not* consist in permitting the storage of very combustible goods without protecting the ceilings with solid plastering, plaster-board, or metal.

IX. It does *not* consist in leaving even the best constructed building in which dangerous occupations are followed without automatic sprinklers and without a complete and adequate equipment of pumps, pipes, and hydrants.

X. It does *not* consist in using any more wood in finishing the building after the floors and roof are laid than is absolutely necessary, there being now many safe methods available at low cost for finishing walls and constructing partitions with slow-burning or incombustible material.

I may name, by the way, the use of fine ribbed glass, twenty-one ribs to the inch, which is now coming into use for glazing factory-windows. This ribbed glass diffuses light, stops the glare, and prevents the heavy shadows from sunlight from passing through clear glass.

There are other slow-burning methods of construction which are practised in Europe, of which we have as yet little knowledge. In my own practice, I am called upon to deal only with the construction of factories and workshops. I have therefore never given that close attention to the construction of floors in the low-priced or low-cost buildings of Europe which might well be given to it. I have observed in passing many methods of constructing floors in cheap dwelling-houses and in low-cost structures, in both England and France, of which owners, architects, and builders in the United States appear to be totally ignorant.

There are many methods of combining coal-ashes and plaster in a substance known in England as "breeze," which is filled in between wooden or light iron joists I have asked many architects what "breeze" was, and I think I have never found but one who could answer the question.* There is also a method of incorporating thin hoop-iron set edgewise with incombustible material, which is supposed to be effective in strength and safety.

My attention has been called to other ways of making ordinary

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*The accident at the "Shoreham," in Washington, two years ago, was caused by the attempt, improperly carried out, to make a fireproof floor by the use of this same "breeze."
E. A.

buildings slow-burning, but time has not sufficed for me to deal with this branch of work. Many of these foreign methods are available here, although we have not the advantage of the soft stone so common on the European continent, which cuts almost like cheese and hardens like iron. If it came within the scope of factory mutual insurance to investigate this matter I should long ago have made a complete study of the subject.

If the young architects who are sent out on traveling-scholarships, or who pass one or two years in Europe at the École des Beaux-Arts, would forego for a time the fine-art study—of which nearly all foreign types are for many reasons wholly out of place in America—and would devote themselves to the prosaic study of how to construct a slow-burning floor in a dwelling-house at low cost, there might be considerable progress in that branch of architecture which has until recently been so much neglected: the art of building at once safely and inexpensively.

I have so far omitted one caution which I find it always necessary to give to those who are not trained in open-timber or mill construction. It is dangerous to paint, varnish, fill, or encase heavy timbers and thick plank as they are customarily delivered, lest what is called dry-rot should be caused by lack of ventilation or opportunity to season.

It follows that if plastering is to be put upon a ceiling following the line of the under side of the floor and the timber, it should be plain lime-mortar plastering, sufficiently porous to permit seasoning. The addition of the skim-coat of lime putty is hazardous, especially if the top floor is laid upon resin-sized or asphalt paper. This rule applies to almost all timber as now delivered, except to vulcanized timber, which, so far as we yet have evidence, is so fully seasoned by the baking of the albumen in the pores of the wood as to be safely subject to being painted or finished when first put up.

The motive of slow-burning construction is to secure the maximum of well-diffused light, the free circulation of air, and the best ventilation, coupled with immunity from danger of loss by fire so far as that can possibly be accomplished without excessive cost. All these points must of necessity be secured at the minimum of cost, as they have been. The present fair standard of cost is seventy-five cents per square foot of all floors occupied including basement, and under favorable conditions somewhat less. Through the evolution of this type of building and long practice on the part of mill-constructors, the slow-burning factory or work-shop of this type, fully meeting all these conditions, costs less per square foot of floor than the buildings of the ordinary construction, which are devised on the methods of what I have named "combustible architecture." Our slow-burning factories are not only stronger, but they are safer and better for use in every respect than any other type of building, and they cost less. We have even coped with the hazard of single floors of more than 100,000 square feet in area. The bane of underwriters in cities is the horizontal hazard. All their efforts are directed to securing small areas of floor-surface and they are apt to devote their attention to this element without giving suitable attention to the more dangerous element of the vertical hazard, or of fire passing from one floor to another.

I will explain this vertical hazard by referring to a very customary type of the most unsafe construction that can be devised, to wit, what is commonly called the stone or brick church, such as the Brooklyn Tabernacle, three times destroyed by fire. These churches are complete expressions of the art of combustible architecture. This so-called stone or brick church consists of an outer shell or sham made of incombustible material. Within this is a wooden structure of the cellular order. The hollow floor of the church is fitted with open wooden ways to the cells of the hollow walls; these communicate with the hollow roof, so that when the wooden fire-box customarily attached to the furnace takes fire from a back draft, the fire has a free way through the wooden flues of floor, wall, and roof to the peak, where it usually breaks out, wholly beyond the reach of the firemen. At the first outbreak the fire is usually out of the reach even of an effective fire-department like that of New York.

Reverting to the main subject, there are no more perfect examples of the art of combustible architecture than are to be found in most of the hospitals, asylums, college-buildings, and schoolhouses. I have never been called upon to inspect more dangerous and unsuitable buildings than some of the larger hospitals, especially one for the insane which we were once asked to protect as far as we could. The power of invention had been exhausted in making that building unsafe and unfit for its use, and that has been the common rule rather than the exception down to a very recent period. Of late several hospitals have been built in the same neighborhood, of the solid, slow-burning type, in which there is no concealed space for fire or vermin. This hospital of a true and safe type has also been so constructed as to meet all the requirements of sanitary science at about one-half the customary amount expended in building hospitals of the usual combustible type.

The penalty and the remedy for the practice of combustible architecture in cities are not being severely applied, notably in Boston and, I believe, in many other cities. The writer has predicted from time to time for the last ten years what would ensue. Conflagrations and excessive losses have followed one after another, the ash-heap of each year exceeding that of the last. This remedy by fire has proceeded until a sufficient number of insurance companies have failed or withdrawn from business to enable the survivors to take effective action for remedying the wrong. Many buildings in Boston are now without tenants because the tenants cannot procure insurance on their contents. The Boston fire-department has distinguished itself for its total incapacity to deal with the fire hazard and the responsibility is now falling where it belongs; namely, (1) on the owners and (2) on the city government, which is so organized or unorganized that no responsibility can be put in the right place in order to secure an effective fire-service. It has therefore seemed to me a good time to call attention again to the simple methods of slow-burning construction, by which we may save a large part of the fire-tax, the measure of which I have attempted to give.

It may be remarked that the highest estimate which has ever been put upon the addition to the annual wealth of the United States, including the rise in the value of land, is $2,000,000,000 a year. That estimate is, in my judgment, excessive, but, assuming that it may be approximately correct and taking one-fourth of that sum as representative of the enhanced value of land, we have a remainder of $1,500,000,000 added to the capital of the country from the products of labor in a given year. Assuming that to have been the addition made last year, it then appears that we burned property equal to 10 per cent. upon this annual saving, and we spent not less than 5 per cent. in a vain and futile effort to save a part of this property or to distribute the loss; yet we call ourselves an intelligent community! I have attributed this loss in varying proportions to stupidity, ignorance, carelessness, and crime, shared also in varying proportions by owners, occupants, architects, and builders. In expressing this verdict, if more severe terms can be found, I think they might be rightly applied.

In a former article in this Magazine * I submitted some plates showing the methods of construction by which the success of the factory mutual underwriters of the more conservative type have reduced the average cost of insurance—losses and expenses—on special hazards, including works which, like some parts of the cotton-mill, are almost explosive in their character, to less than twenty cents a year on each $100 insured for the last ten years. We do not solicit insurance. We limit our work to New England and the middle states, and to the specific classes of risks with which we are familiar. Nearly every one of these risks which is fit to be insured by us within this area is now included in our lines. These plans and specifications have been developed in a long period of time by some of the most skilful and

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* On "The Park Place Disaster," November, 1891.

competent mill-engineers and constructors of factory-buildings in the United States. It has simply been my function to bring them into a comprehensive form and to adjust the conditions of all our risks to these types.

The danger of the loss of life from fire in the factories which are insured under our supervision has been wholly removed so far as it rests upon means of escape or avoidance of danger other than mere personal accident. I do not know what the exact statistics of loss of property and life in proportion to number and value of all risks would show; but, so far as the data at my command give a basis, they prove that the special hazards of textile-factories and paper-mills under our supervision have been so far guarded against as to make them better risks and subject to less danger than the average hospital, asylum, dormitory, or college-building.

When I first began investigating this subject, many years ago, the average destruction of this latter class of buildings was one a month. On a second and later examination it appeared that the masters of combustible architecture had gained heavily on that rate; the losses were one every two weeks. From the latest data, I believe a further gain has been made, and the customary destruction of this class of buildings is probably one a week, often with the cremation of several inmates. Combustible schoolhouses may also be brought into this comparison, being sometimes destroyed, as lately in Evanston, Illinois, with a heavy loss of life. All these dangerous conditions are remediable at lessening cost of construction by the application of mere common sense to the problem. Under such circumstances I think I am justified in the severity of the words I have selected to describe the present conditions.

THE MODERN BATTLE-SHIP AS A FIGHTING-MACHINE.

By George W. Melville,

Engineer-in-Chief, United States Navy.

IF an author had started to write of fighting-ships a hundred years ago he could not have selected the caption of this article. At that time ships were truly what they are sometimes still called,—gun-platforms and transports for fighting-men. Those were the days of close-range conflicts, when the guns were fired almost with muzzles touching, and many a battle was a hand-to-hand contest decided by mere physical strength, the decks of the ships serving as a field, just as in warfare on shore. The change to existing methods has been very gradual, but the days of "boarding" have gone never to return, because the modern battle-ship has become—not figuratively but in reality—a fighting-machine. The emphasis here is to be laid on the last word, and its significance will become apparent on further consideration.

In the old ships *personnel* was everything; *matériel* was almost nothing. In the modern ships the conditions are almost reversed, and, while *personnel* is still indispensable as the directing power, *matériel* has assumed such importance as almost to dwarf it. To an engineer the consideration of the modern battle-ship is fascinating, for it is his creation throughout. He furnishes the material, he fashions every part, and without him its successful use would be impossible. We have the metallurgical engineer who furnishes the material; the ordnance engineer who makes the guns and armor; the marine engineer who builds the main and auxiliary machinery; the hydraulic engineer who supplies the hydraulic apparatus; the electrical engineer who installs the lighting-plant; and the naval architect who builds the hull, for I count him an engineer as truly as the bridge-builder is one.

Every machine includes a carefully-designed framework adapted to support the moving parts and withstand the stresses coming upon it and the moving parts which make it almost a living thing. The battle-ship answers to this definition exactly. The hull is the framework, and its proper design offers a field for the highest professional skill, while the moving parts are engines of all sorts and sizes and for almost every conceivable purpose.

The hull must be strong enough to carry guns, armor, coal, and machinery, to withstand the stresses due to heavy weather, and it must be almost unsinkable. All these conditions make it a very complicated structure, with its numerous bulkheads and water-tight compartments. It has often been said that a war-ship is a series of compromises, and a study of the differences of opinion of eminent designers even at the present time makes this very clear. Ever since the introduction of armor there has been a steady fight between it and the gun, first one and then the other being ahead. At first it was possible to armor the whole side above water as well as to give special protection to the guns and machinery, but with the progress of ordnance the thickness of armor required to give adequate protection has become so great that it is impossible to armor the vessel throughout her length. This has led to the design of central citadel ships where the armor is concentrated at the middle of the length, protecting guns, magazines, and machinery, leaving the ends almost entirely unprotected. In the great Italian battle-ships this has been carried to the point of confining the protection strictly to the big guns, magazines, and machinery, leaving even portions at mid-length unprotected. Many competent critics contend, however, that such vessels are very vulnerable and that an attack of the unarmored ends by rapid-fire guns in the region of the water-line would speedily let in so much water as to render the vessel unmanageable if, indeed, she did not capsize like the unfortunate *Victoria*.

Probably few except those specially interested in the design of naval vessels have any idea of the weight given to armor in the battle-ship, and the following summary of the distribution of weights in our sea-going battle-ship, the *Iowa*, will be interesting :

	Tons.
Hull and fittings	4540
Protection, including armor, protective deck, and water-excluding material	3630
Armament and fittings and ammunition	1000
Machinery, stores, spare parts, etc	1170
Coal at normal displacement	625
Crew, equipment, outfit, stores, etc	325
Total	11,290

From this it will be seen that almost exactly one-third of the entire weight is given up to protection. The distribution of armor in this vessel is as follows : Protection of the hull against injury to the water-line region is to be secured by a side armor belt 14 inches thick and 7.5 feet deep. The transverse armor at the ends of the belt will be 12 inches thick. Barbettes and turrets for 12-inch guns will have armor 15 inches thick, and the ship's side, from the armor belt to the main deck, will have a thickness of 5 inches. An armored deck, 3 inches thick, is to extend forward and aft from the ends of the armor belt.

The conning-tower will have 10-inch armor, and will be connected to the armored deck by an armored communication-tube 7 inches thick. The barbettes of the 8-inch guns will be 8 inches thick on the exposed side and 6 inches elsewhere, while the turret armor will be 6 inches thick. These turrets will have armored supporting tubes 3 inches thick arranged to protect the ammunition hoists. The 4-inch guns will have shields 4 inches thick.

Thus far we have been considering the defensive side of the fighting-machine, because the battle-ship must be able to receive as well as to give blows. We shall now consider the offensive side or those features which fulfil the idea that the machine is to fight.

Most modern battle-ships include the three great weapons of attack, the gun, the ram, and the torpedo, and each is a machine in itself. Special vessels have been built in which one of the last two is the only weapon, this feature being carried out to the greatest extent in the torpedo-boat, which has been multiplied by the score in the navies of all first-class countries but the United States. Only a few rams, where that is the only weapon, have been built thus far, although that accomplished naval officer, Admiral Ammen, believes that fleets of rams should form our principal class of vessels. In the battle-ship, the ram and the torpedo are regarded as secondary weapons, the main reliance being upon the gun. It is not hard to understand why this should be so. The ram and the torpedo are effective only against other vessels and they must be used at close range, the former by the very nature of things. The gun is effective at long range and against fortifications as well as ships.

At one time it seemed as though the increase in size of guns was to be without limit, and there are actually afloat to-day a number of guns weighing from 100 to 110 tons. This enormous weight, moreover, is that of the gun alone. When its mount and fittings are included the figures would be increased more than half. Experience has shown, however, that this was going too far, and the limit now appears to be about 13.5 inches caliber and 67 tons weight. Only a few full charges, comparatively, can be fired from one of these monster guns before it must be relined at great expense. The exact number is not definitely known, but is put at fewer than fifty. As an exhibition of enormous power, however, the figures for the firing of one of these guns are awe-inspiring. The projectiles weigh nearly a ton and cost about $750. The powder charge is nearly 1000 pounds and costs about $325. The projectile leaves the gun with a velocity of about 2000 feet per second, having an energy of about 50,000 foot-tons.

An interesting test of an Armstrong 110-ton gun was made in 1891 against a Brown armor-plate 7 feet square and 20 inches thick, at the back of which was a wrought-iron plate 8 inches thick, and both backed by 20 feet thickness of oak beams and 25 feet thickness of granite, concrete blocks, and brick masonry. The gun was 500 feet from the target. The powder charge was 950 pounds; weight of Holtzer armor-piercing projectile 1813 pounds; muzzle velocity 2079 feet per second, giving a striking energy of 54,320 foot-tons. The projectile struck the center of the plate and perforated the compound plate, the wrought-iron plate, the 20 feet of oak backing, 5 feet of granite, 11 feet of concrete, and finally came to rest after going through 6 feet of brick masonry. We must remember, however, that the gun was only 500 feet away and the target rigid. It is very unlikely that such a favorable chance for the gun would occur in a sea fight.

As already remarked, it is now agreed that smaller guns are better adapted to use at sea, and the following comparison, published by the office of naval intelligence at Washington, shows how a smaller gun may equal the effect of the larger one if it give greater velocity to the projectile.

MAKER.	Caliber. Inches.	Weight of Gun. Tons.	Weight of Projectile. Pounds.	Muzzle Velocity. Feet per sec.	Pressure in powder chamber. Tons per sq. in.	Total energy. Foot-tons.	Muzzle penetration of wrought iron. Inches.
Armstrong....	16.25	110.5	1800	2148	19.5	57,570	37.98
Krupp.......	15.75	119.	2028	1804	14.7	45,756	30.90
Canet.......	12.60	65.	993	2386	16.1	39,187	31.93

It will be readily understood that such projectiles and charges as these can not be moved by hand-power, and, in fact, everything about these big guns—hoisting the projectile and charge, loading, training, and giving the elevation—is done by machinery. The gun itself with its attachments forms a highly-complicated machine towards whose perfection some of the ablest minds in the engineering world have devoted themselves entirely.

As we descend the scale of sizes, hand-power becomes available, but not directly. Every modern gun, however small, remains a machine, and so true is this that a special class, its members bearing the names of various inventors, has arisen to which the specific designation "machine-guns" has been given. These little weapons make the figurative expression "leaden rain and iron hail" a plain matter of fact. Our own Gatling gun was among the first, but the machine idea seems to have culminated in the Maxim gun, which, when once started, continues to work automatically until the supply of ammunition is exhausted. Intermediate between these and the great guns are the rapid-fire guns, an adaptation to moderate calibers of cartridge ammunition. These are now built up to 6-inch caliber and have practically displaced the ordinary breech-loaders for these sizes. The increase in rapidity of fire is very marked, trials of 6-inch rapid-fire guns having given repeated records of ten aimed shots inside of two minutes, while smaller calibers give still greater rapidity. One record of a 12-centimeter rapid-fire gun showed ten rounds in 54 seconds.

The battery of the *Iowa*, to which reference has already been made, consists of four 12-inch breech-loading rifles; eight 8-inch breech-loading rifles; six 4-inch rapid-fire guns; twenty 6-pounder rapid-fire guns; four 1-pounder rapid-fire guns; four machine-guns; one field gun. The 12-inch guns are to be mounted in two barbette turrets, one forward and one aft on the center-line. The axes of the forward guns, when horizontal, will be 25 feet above the water-line, and those of the after ones nearly 18 feet. The guns of both turrets can fire through an arc of 270 degrees. The 8-inch guns are to be mounted in four barbette turrets, two on each broadside. Their axes will be 25 feet above the water-line and each gun can be trained through an arc of about 170 degrees. The smaller guns are distributed in various parts of the ship, two 1-pounders and the machine-guns being located in the "military tops."

The battery of the *Royal Sovereign*, one of England's finest battle-ships, comprises four 67-ton, 13.5-inch, breech-loading rifles, ten 6-inch rapid-fire guns, twenty-four 6-pounder and 3-pounder rapid-fire guns. The total weight of armament is 4100 tons, and of armor 4550 tons. The armor belt is 250 feet long. The displacement is 14,150 tons as compared with the *Iowa's* 11,290. The latest class of English battle-ships consists of seven vessels of 14,900 tons. They will carry four 12-inch breech-loaders, twelve 6-inch and sixteen 12-pounder rapid-fire guns. From these comparisons it will be seen that the *Iowa* carries a very heavy battery.

Much has been said of the ability of powerful battle-ships armed with heavy guns to shell New York while lying at sea, and it is interesting to note that actual experiment has shown a range for 12-inch guns of over ten miles.

We have now noticed the means for fighting in the battle-ship, but all these costly and intricate machines would be either helpless or useless except for the other machines, down in the bottom of the ship, which furnish the power to these and also give the element of mobility without which the vessel would become simply a fortress on the water.

The boilers are, after all, the most vital element in the ship. Unless they are efficient no degree of excellence elsewhere will avail. It is little wonder, therefore, that they, as well as the propelling machinery and the magazines, are well protected by heavy armor. They supply not only the main engines but a host of auxiliary engines which have grown in number and importance until, in the modern fighting-machine, this term is almost a misnomer. In the great Italian battleships *Re Umberto* and *Lepanto* the main engines are of 19,500 horsepower, while the so-called auxiliaries foot up 2480 horse-power, a considerable fraction.

As in every other part of a modern ship, there has been progress in the design and construction of the boilers. The most familiar type, the cylindrical, has grown in size until one double-ended boiler will be 17 feet in diameter by 21 feet long, weighing, with its contained water, about 140 tons. On board ship weight is precious, and great pressure has been brought on the designers of the main machinery to reduce weights to the lowest point. With the boilers much has been done in this direction by the use of forced draft for the fires, which enables 50 per cent. more power to be obtained on the same weight without undue forcing. Just now we seem on the eve of a radical change in the type of boiler, the new one being composed of many small, thin tubes containing only a little water, so that for the same weight more than double the power can be obtained. The new type of boiler possesses other advantages. It is safer against explosion, it raises steam more quickly, and it can be forced with safety as hard as desired.

As long ago as 1888 the United States navy department took the first steps toward a practical test of boilers of this type under actual service conditions, and the *U. S. S. Monterey* is the first battle-ship whose boilers are largely composed of the water-tube type. All the other countries with great navies are now taking up the subject, and it seems probable that, in a few years, water-tube boilers will form the principal part of the steam-generating plant of all war-vessels.

In past years, the boilers were treated rather badly. The demands of regular service were not severe and the consequences of neglect were not so disastrous. Now, the intelligent and tender care of the boilers is the first thought of the competent engineer.

The propelling engines do not differ greatly in general features from those of the great ocean flyers, but there are many differences of detail. Here, as in the boilers, reduction of weight has been carried as far as possible. This has led to short-stroke, quick-running engines as contrasted with the long-stroke, slow-running ones of the merchant service. This requires greater care and attention to bearings to insure absence of heating. It has also made necessary proportions of cylinders which prevent the attainment of as great economy in the use of steam as obtains in the merchant service. Space forbids an extended consideration here of this very important item, but it may be mentioned that in machinery, as in so many other things about a naval vessel, the existing method is a compromise. Economy is as much desired in naval machinery as in any other, but the most important thing is to get the power in the vessel for as little weight as possible. The two conditions are incompatible, and economy, as the less important, has to yield.

Naval vessels were the first to adopt twin screws generally. Their advantages for a machine built primarily for fighting in greatly increased facility of maneuvering are obvious, as is the additional advantage of offering greater security against total disablement. There are others, such as smaller engines and smaller individual parts, with greater assurance of soundness, that will appeal to any engineer at once.

The auxiliaries have already been mentioned as playing a very important part. Their nature and number is well shown by the following list of those on the *Re Umberto :*

MACHINES.	Number of machines on board.	I. H. P. (working full power) per machine.	Total power.
Main hydraulic pumps	2	160	320
Auxiliary hydraulic pump	1	80	80
Steering engines	2	100	200
Capstan engine	1	160	160
Steam winches	2	50	100
Dynamo engines	4	25	100
Air-compressing pumps	2	30	60
Fire pumps	2	30	60
Circulating pumps	4	60	240
Main-feed pumps	4	40	160
Auxiliary-feed pumps	6	40	240
Bilge pumps	4	30	120
Air-pumps	2	70	140
Fire-room blowers for forced draft	12	20	240
Ventilating fans	8	10	80
Turning engines	2	25	50
Reversing engines	2	25	50
Pumps for auxiliary condensers	2	20	40
Ash-hoist engines	6	5	30
Workshop engine	1	10	10
Total	69		2,480

From this it appears that there are no less than sixty-nine separate engines, and if the individual cylinders were counted they would exceed 150. The sizes of some of these auxiliaries are very respectable, the main air-pumps and the hydraulic pumps of some of the large ships being actually larger than the propelling-engines of some of the small gunboats. The great amount of steam-piping necessary and the difficulty of leading it conveniently in all cases have led to the suggestions of driving the auxiliaries by electricity, compressed air or hydraulic power. A careful analysis of the subject by Colonel Nabor Soliani, of the Italian Naval Engineers, shows, however, that steam is both cheaper and involves much less weight than the other methods. Mr. Dickie, manager of the Union Iron Works of San Francisco, has, however, shown that another form of hydraulic transmission, which uses high-speed motors, would weigh as little or less than steam machinery for the auxiliaries.

That the battle-ship is a fighting-*machine* becomes more than ever apparent from considering the list of auxiliaries. Not only does the working of the guns and the supply of ammunition depend on machinery, but the weighing of the anchor, the steering of the vessel, the ventilation, the lighting, the heating, and the cleansing, even the supply of water for drinking and its cooling, all are done by machinery. In fact, the great machine is a steam being, and as long as it is properly fed on its appropriate food, coal, it does its work. That is, when it is in health; but, like human beings, it gets ill and needs its physician, the engineer. It is, however, better treated than human beings, for its physician watches it carefully to see the first signs of anything amiss with the complicated mechanism, and applies the remedy at once.

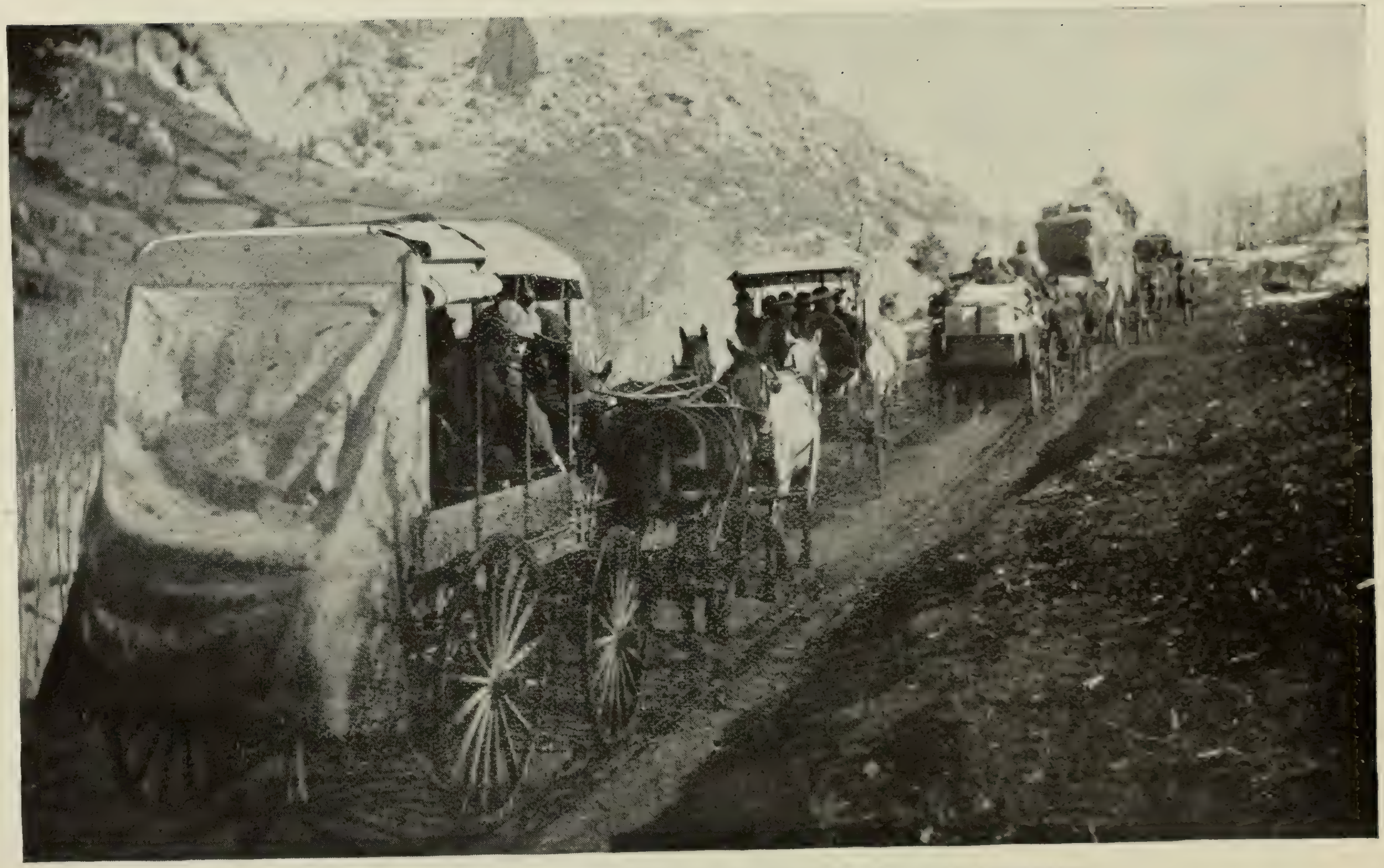
It may occur to the thoughtful reader to ask why such costly machines as battle-ships are necessary to a navy, and why, if they are necessary, we can not get along with monitors, or small vessels like the *Maine* and the *Texas*, of less than 7000 tons. This question has been debated again and again, and the general agreement is that large battle-ships are necessary. As very cleverly put by Mr. Lewis Nixon, the accomplished naval architect to the Cramps, "You can't get as much fight out of two millions as out of five." In other words, to carry heavy guns to deal heavy blows and to protect them by thick armor so as to be able to stand up against an equally powerful antagonist, we must have a large ship. A small one can't carry the weights. A monitor is an attempt to do this on the least displacement, but she could not fight at sea and she can't carry coal enough to go anywhere. The *Monterey* could not go to Honolulu without carrying coal in bins on deck. She is not meant for that service, however, as she was specially designed for coast-defense.

The great fighting-machine is meant to be able to defend the flag anywhere, at home or abroad, and to fight at sea or in harbor. If all nations would agree upon a type of small vessel and limit themselves to that faithfully, then battle-ships might be built smaller or abandoned. Until then, every first-class power must have them. There must, however, be some limit as to size. Sir Nathaniel Barnaby, for many years the director of naval construction of the British navy, said in a paper last year at the International Engineering Congress:

> I think it also reasonable to say that, excepting a few large and powerful ships, designed, not for line-of-battle but as station ships or naval centers at outlying places of importance, no ship can be regarded as the best ship of war which, being liable to be lost by touching a rock in smooth water, by the attack of a torpedo-boat, by the blow of a ram, or by an internal explosion, may thereby cause the loss of a crew exceeding (say) four hundred men.

In conclusion a few words may be said regarding the appropriate crew of this fighting-machine. For many years it has been the belief that our war-vessels could and would always be recruited in an emergency from the sea-faring population of our eastern coast, notably the fishermen and whalers of New England. This was well enough in the days when sails were an important means of propulsion and guns were the small and simple affairs of thirty years ago, but these men know nothing of machinery and are really out of place on the fighting-machine. Of seamanship in the old sense, very little is required. A score of sailor-men of the old type would suffice for doing duty as quartermasters and wheelmen, while the rest of the crew should be men with more or less mechanical training,—the more the better. Instead of recruiting from the fishing smacks, we should draw upon the machine-shops and locomotive-shops throughout the country, thus obtaining men to whom the handling of machinery is thoroughly familiar. This is exactly what is done in the countries of continental Europe which have compulsory military services. The young mechanics, instead of going into the army, enter the navy, where the work is congenial and similar to their own, and it gives a body of men capable of the highest efficiency. Much has been said about the versatility of the sailor of the old type, but all his training is directly opposite to what is required of the man-of-war's man on the fighting-machine.

The officers, too, need a different training from that of thirty years ago, and a beginning has already been made at our naval school towards what many believe will be the ultimate outcome, when every officer will be a trained engineer. Even now the young line officers receive considerable instruction in mechanism and practical handling of tools, and the requirements of the fighting-machine are compelling every officer who would be at home there to supplement the defects, from an engineering standpoint, of his early education. We already have the fighting-machine itself developed almost to perfection, and, with men and officers properly trained and enthusiastic about their ship, we can safely count on a future for our navy in which the brilliant record of the past will be maintained with undiminished luster.



NEW SETTLERS ON THE ROAD TO THE CRIPPLE CREEK GOLD-CAMP, COLORADO.

COLORADO'S NEW GOLD-CAMPS.

By Prof. Arthur Lakes.

THE fall in the price of silver has naturally given a greater impulse to the search for gold. In the past two years gold has been found in Colorado in places where its existence was before unsuspected. One might almost think that nature had accommodated herself to the altered state of business affairs, for in some of the long-established camps we hear of veins changing from silver to gold with depth or extension. This seeming condescension on her part may be attributed mainly to the fact that, in silver-camps or silver- and gold-camps, we never hear nowadays of a silver-mine. But we do hear, without delay, from every mine that can produce a little gold. If a mine was gold-bearing as well as silver-bearing before the crash, we now hear only of its production of gold. It is a fortunate and remarkable coincidence that the ore-bodies of some mines, hitherto silver-bearing only, with extension or increased depth have passed into a gold-bearing combination. In most cases gold is found because gold alone is sought, and gold is heard from because we are interested in gold.

Since the fall in silver, and more especially since the general panic of 1893, great numbers of prospectors have been at work—either on their own account or else "grub-staked" by others—many of whom were well-to-do before the crash, but whose coffers are now depleted. Besides these professionals, with the retreating winter snows a horde of all classes and conditions has been scattered over the mountains in a happy-go-lucky kind of prospecting. Some of these are well-educated business men, who have been compelled by the hard times to shut down their business and take to the mountains as a last resort. With these are a great many of the unemployed laboring class. Probably nine-tenths of this crowd know nothing about prospecting, but it will be strange if, in a country so prolific in natural resources, they do not find something before another year is ended.

Among the various recent discoveries, the gold-field of Cripple Creek stands at present far above all others. The Cripple Creek field is not the product of that necessity which we are told is the mother of invention. It happened that, as if to forestall a coming catastrophe, the gold value of Cripple Creek was discovered nearly a year before the storm burst.

In 1891 two important camps came into existence in Colorado almost at the same time—Creede, a silver-camp, and Cripple Creek, a

THE FIRST CABIN IN CRIPPLE CREEK.

gold-camp. While Creede rapidly inspired confidence in its value and permanence by the strength of one or two of its rich silver-bearing fissure veins, Cripple Creek was slower in its advance, and business men were cautious about investing heavily in the new gold-field. Scientific men were divided on the subject of the permanence of the ore, and even of the depth of the veins ; nor are we in a position even now, after more than a year's development, to be positive one way or the other. The nature of the camp is not yet absolutely proved. Few of the so-called mines which so far have produced well near the surface have, by sufficient depth or extension, attained to the dignity of what may be called "true mines," but most of them are "prospects" on a large scale. The depth of the mines in the camp rarely exceeds 200 feet, and the amount of development is rarely over 1000 feet. Few mines have penetrated to or below water-level, where important changes in the character of ores from a decomposed and free-milling character to one undecomposed, sulphid, and smelting commonly take place. Nor has the lateral extent of the ore deposits been satisfactorily shown by any one mine, though more has been done laterally than in depth. On geological grounds, and from results already attained, the most that can safely be said is that the promise of continuity of the ore-deposits and the prospects of the camp in general are favorable.

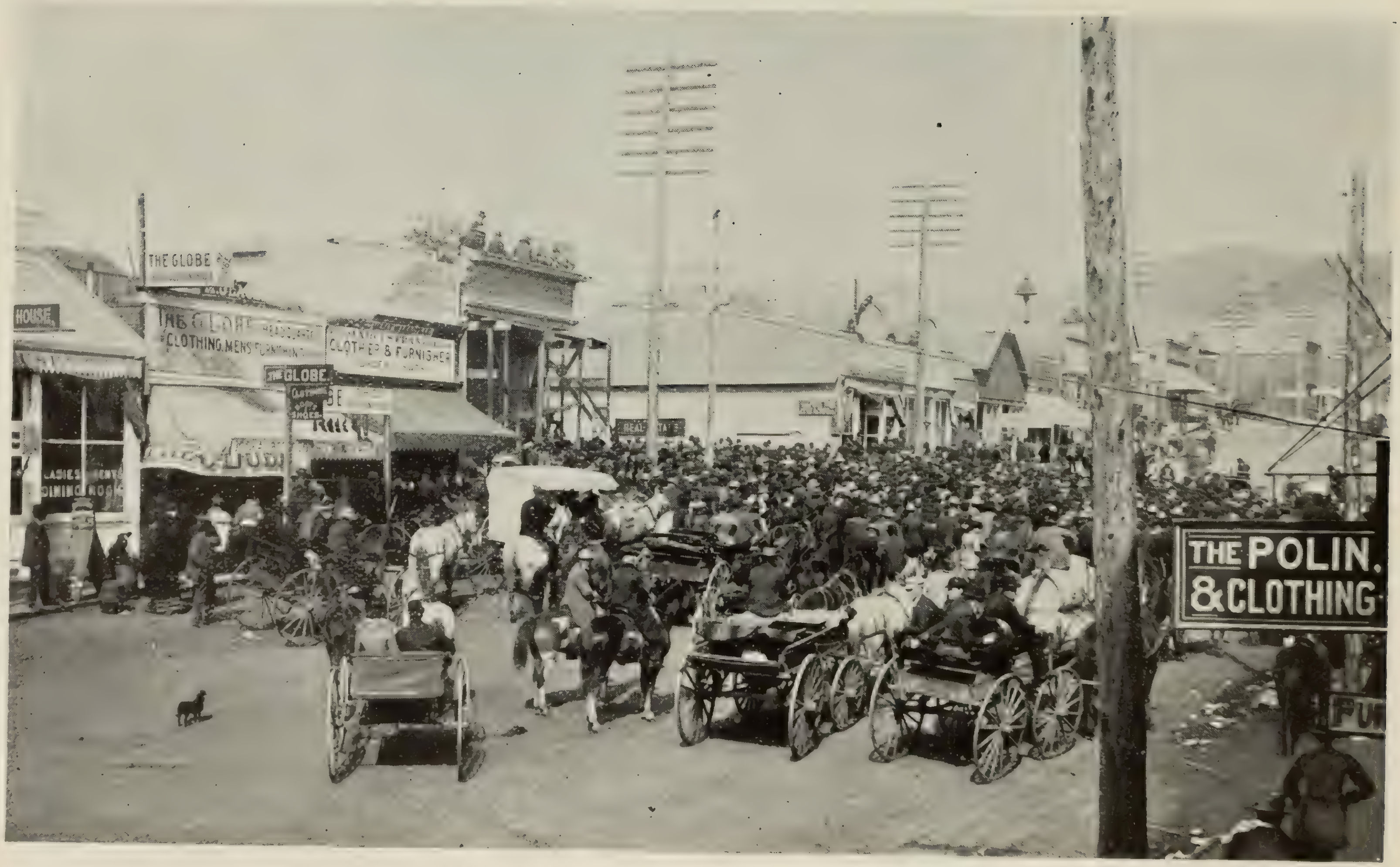
The quality of the mines might by this time have been well shown up and proved had it not been for the delay in their development by the late long-continued and unfortunate strike just at the time when confidence in the camp hung in the balance, and when gold was so

A VIEW OF CRIPPLE CREEK

PROSPECTING PARTY AT CRIPPLE CREEK.

badly needed in Colorado and throughout the country. Yet the number of shipping mines and the value of metal already shipped are remarkable for so young a camp, and speak well for its future. It is not unreasonable to expect great things from this camp now that the ban of the strike is removed, and the mines are again in operation. Hundreds of prospect holes with which the hills are speckled, as by an army of moles, are to be developed and their prospective value more nearly ascertained. Then the arrival of two competing railroads into the district will materially help, reducing the expenses of freight on the shipping ores, and causing to be profitably utilized a vast amount of low-grade ore now lying on the dump or in the reserves.

While one can count with some confidence on the permanence of a newly-discovered silver-camp, such as Creede, located on large fissure veins, after a few feet of development, one cannot as a rule depend with equal confidence upon a new gold-field, although the first few feet below the surface may be extraordinarily rich. The value of a gold prospect cannot be fairly prognosticated until the water-line, or the depth to which surface action attains, has been reached. The ores above that point are commonly oxidized, and the gold set free and able to be treated by the cheap and simple process of stamping or free milling. When this surface action ''plays'' out, which may be from a depth of a few inches to many feet, the ore is usually found in its unoxidized, unaltered state as a sulphid of iron or iron pyrites,—in the case of gold, with the gold shut up in its matrix of pyrite; in the case of silver, in a sulphid of lead or unoxidized galena. To extract the gold from its matrix demands a much more expensive process than



PRINCIPAL STREET IN CRIPPLE CREEK—STRIKERS LISTENING TO A HARANGUE.

PANNING GOLD AT CRIPPLE CREEK.

ordinary stamping, which may be done close to the mine,—namely, smelting or roasting, involving transportation to some place where fuel and fluxes are near at hand. Hence, while free gold in the oxidized upper portion of a vein may be milled with profit, though it runs but a few dollars, the unoxidized ore at greater depth has need to be much richer to stand the greater expense of the new treatment. As a matter of experience, the unoxidized ore proves often too poor in gold to pay, notwithstanding that the upper and oxidized part of the vein may have been phenomenally rich in free gold and gold specimens. The natural reason for this is that the upper portion of the vein represents the products of natural milling, lixiviating, etc., carried on possibly for thousands of years.

Hence the caution in not banking too quickly on the permanence of an undeveloped gold-field, and the unwisdom of erecting large and costly stamp- and other mills, on the strength of the richness of a few surface prospects. Thus at Cripple Creek, when the prospects were first opened, a good deal of the surface ore was free gold and free milling. Stamp-mills immediately swarmed, and a concern large enough to monopolize all the milling in the camp was erected by European capital. Very soon it was found that somehow these mills came only within 40 per cent. of the value attained by assays. In other words, they lost nearly half the miner's gold. It was then discovered that only a small percentage of the gold was free milling, and that mainly near the surface. With depth the gold was associated with a matrix of tellurium and was suitable, not for stamping, but for smelting. The result was that soon nearly every mine was shipping most of its ore to the smelters at Denver or Pueblo. The stamp-mills at present treat only a small fraction of the general ore, and principally that which is low grade. Experiments of all kinds have been tried on this ore in the camp itself. The most likely one seems to be the cyanide or MacArthur process, which, after reducing the ore to fine particles, dissolves the gold in a bath of cyanide of potassium and precipitates it upon zinc shavings, and separates the gold from the silver by the ordinary cupel and roasting furnace. They claim to be able to save 91 per cent. of the gold by this treatment.

Another reason for not banking too hastily on the permanence of the camp was the peculiar geological occurrence of the veins and ores, so different from those elsewhere that a geologist could not prophesy one way or the other by comparing them with those of any other gold-mining district in the west. Some geologists thought the so-called fissure veins or zones of impregnation were "gash" veins and would be limited to the depth of the lava sheets. Others believed them to extend down into the underlying granite to an unknown but certainly great depth. The latter view is probably the correct one, for on the skirts of the volcanic area we find many veins and mineralized dikes ascending through the granite of a similar character to those in the volcanic sheets. No mine has yet penetrated deep enough in the volcanic material to absolutely prove or disprove either hypothesis. Granted that the continuity of the veins with depth is reasonably assured, it is still

SLUICING AND PANNING GOLD.

an open question whether these veins will become richer or poorer with depth. There are mines in the camp, the size and richness of whose surface ore-bodies used to be in every one's mouth, which are now with depth hunting for their ore-bodies which they are supposed to have temporarily lost. In other mines an exactly opposite state of things is the case. This uncertainty, however, is not uncommon in other mining camps of older date. In the present case, considering the age and slight development, the balance is rather favorable than otherwise.

Cripple Creek is situated near the western base of Pike's Peak, at an elevation of 9400 feet above the sea. It is about twenty miles southwest of Colorado Springs, one hundred miles from Denver, and forty-four from Pueblo. The district is characterized by smooth, rounded, rolling hills, sparsely wooded, intersected by numerous small valleys and gulches. The productive area, which is constantly being enlarged on its outskirts by fresh discoveries, is about six miles long by three miles wide and comprises about eighteen square miles. The float, or oxidized, porous, rusty rock, purple-streaked or ocher yellow, which so abundantly covers the hills, early attracted the attention of passing prospectors, but as they could locate nothing "in place" from which this float came, nothing was done in development. In the "sixties" Dr. Hayden's geological exploring parties passed over the area and scanned its geological features, but appear to have had no suspicion of its metal-bearing qualities. In 1874 a shaft was commenced in Arequa Gulch and abandoned at a point near which there are now good mines. In 1879 a tunnel was begun in Poverty Gulch which just managed to miss the ore-bodies of the present Gold King, one of the richest mines in the camp.

In February, 1891, some Colorado Springs men determined to test the district and took up several claims which promised so well that, during the following spring and summer, news having spread that there was something in Cripple Creek, many prospectors flocked in, and by the close of the year there were 2000 people scattered over the region like a pack of hounds hunting a fox. By March there were 4000 people, and by June 8000. During 1892 the progress of the camp was rapid, work being confined mainly to the location and establishment of claims, and testing their values. In the course of that year some ten or a dozen mines became regular shippers, and their output reached a total of $583,000. In 1893 the total production was $2,406,980, of which $350,000 was for the month of December alone.

Thus, in a remarkably short time after its discovery, the camp developed from prospect holes, assay and mill-run tests, into a regular producer and shipper. The main obstacles were high price for treatment, saving of values low, cost of shipment high, the peculiarities of

GREATEST STRIKE IN CRIPPLE CREEK.

[An Ore Body in Brecciated Lava, 33 feet down. Camilla Mine.]

the ore we have alluded to, and not enough development to prove permanence and warrant large investment. Added to this was the absence of railroads. It was soon found to be, in one respect, a "poor man's" camp, because pay-ore was often found at "grass-roots"; on the other hand, with depth, the ore was found to need an expensive mode of treatment.

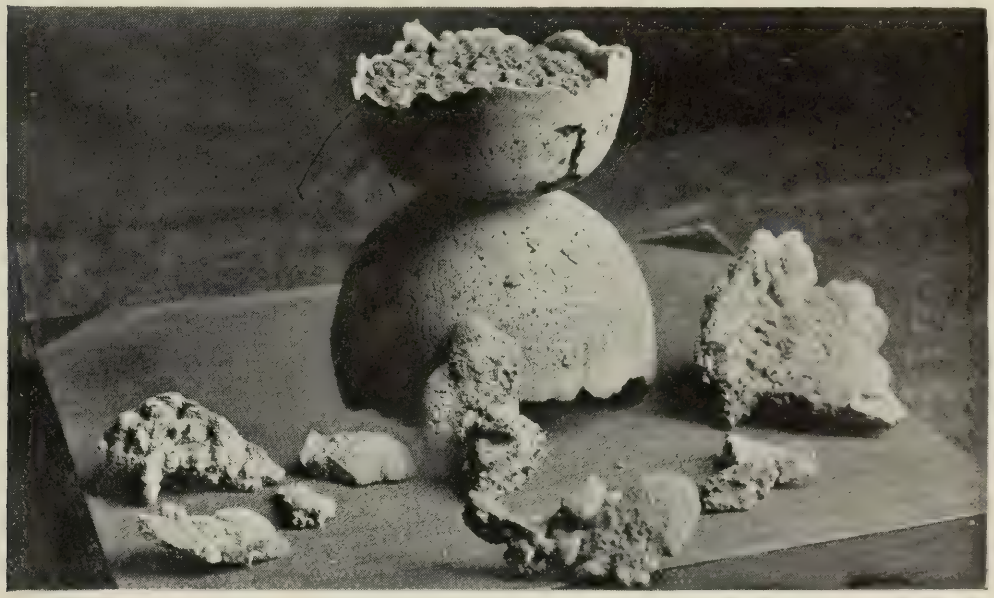
The social condition of the camp at this time is thus sketched by a western newspaper: "'There are psalms on the hill-side in a gospel tent, with 'hi, hi, hi! keep her going' down below; a prayer-meeting in one tent and in the next 'raising of old Ned right out by the hair.' Families, women, and children are beginning to come in. Every one comes to work for himself, and put down a hole somewhere. They come by coach and scatter over the hills. A court-house in a frame cabin is erected, and the camp boasts a justice of the peace, a constable, and other 'frills.' The consequence of this painful state of affairs is that no one is allowed to carry a gun. A shocking falling away from frontier standards and depressing to Easterners who pack in their arsenal on a mule in order to be 'properly bad.' Old-time miners shake their heads gravely and doubt if the camp will be any good because no one is killed yet."

As regards the general geological features of the mining region, it is an oval area among the lower granitic hills at the base of Pike's Peak; covered in places to a considerable depth—probably a thousand feet or so—by volcanic lavas resting on granite, doubtless filling many an old waterworn granitic valley and submerging many a granite ridge and peak. This lava may be of two or three or more varieties, representing successive and different flows, from many different fissures and orifices. The prevailing rock is a grey volcanic *breccia,* composed of angular fragments of lava, cemented together by a lava paste. These flows appear to have been penetrated by dikes of more recent lavas ascending through fissures. These dikes and fissures are the principal ore-carriers. On the outskirts of the volcanic sheets, where erosion has removed the surface lavas and bitten deep into the under-

GOLD KING MINE, AT CRIPPLE CREEK.

lying granite, we find the stumps of numerous mineralized lava dikes disclosing some of the sources of the lava flows. Still later movements appear to have taken place, opening fissures and shattering the rocks. These fissures and the crevices in the shattered rocks were filled with ore and vein matter, forming the so-called veins or impregnations. The varieties of lava have not yet been scientifically determined, but they are generally supposed to be phonolites and andesites, together with some eruptive and porphyritic granitic.

The ore-deposits for the greater part occupy lines of fracture and fissure in the lavas, or impregnate lava dikes. Some occur in fissure veins in coarse red granite, or at the junction of granite with a lava dike. The ore fills the interstices in a lava dike, or occupies a fissure in the lava sheets. Or it occurs in sandy, clayey matter on either side of a dike, or it occupies the line of a fissure between more or less distinct walls, running off into every available crevice of the shattered wall rock—more often lining the faces of crevices than permeating the rock itself. In some mines there is but one vein or line of mineral impregnation; in others, two or three distinct and parallel zones or veins. The prevailing strike or direction of the veins, as well as the dikes and cleavage of the granite, is to the north and south, or a little east or west of north; the dip is usually very steep, often nearly vertical. Occasionally there are cross veins having an east and west direction. The veins are liable to be faulted, to fork and split, and to enclose "horses." In some mines the ore-body is so scattered among the crevices of the rock that none of the veins are large enough to work separately, or pay to work collectively. Large



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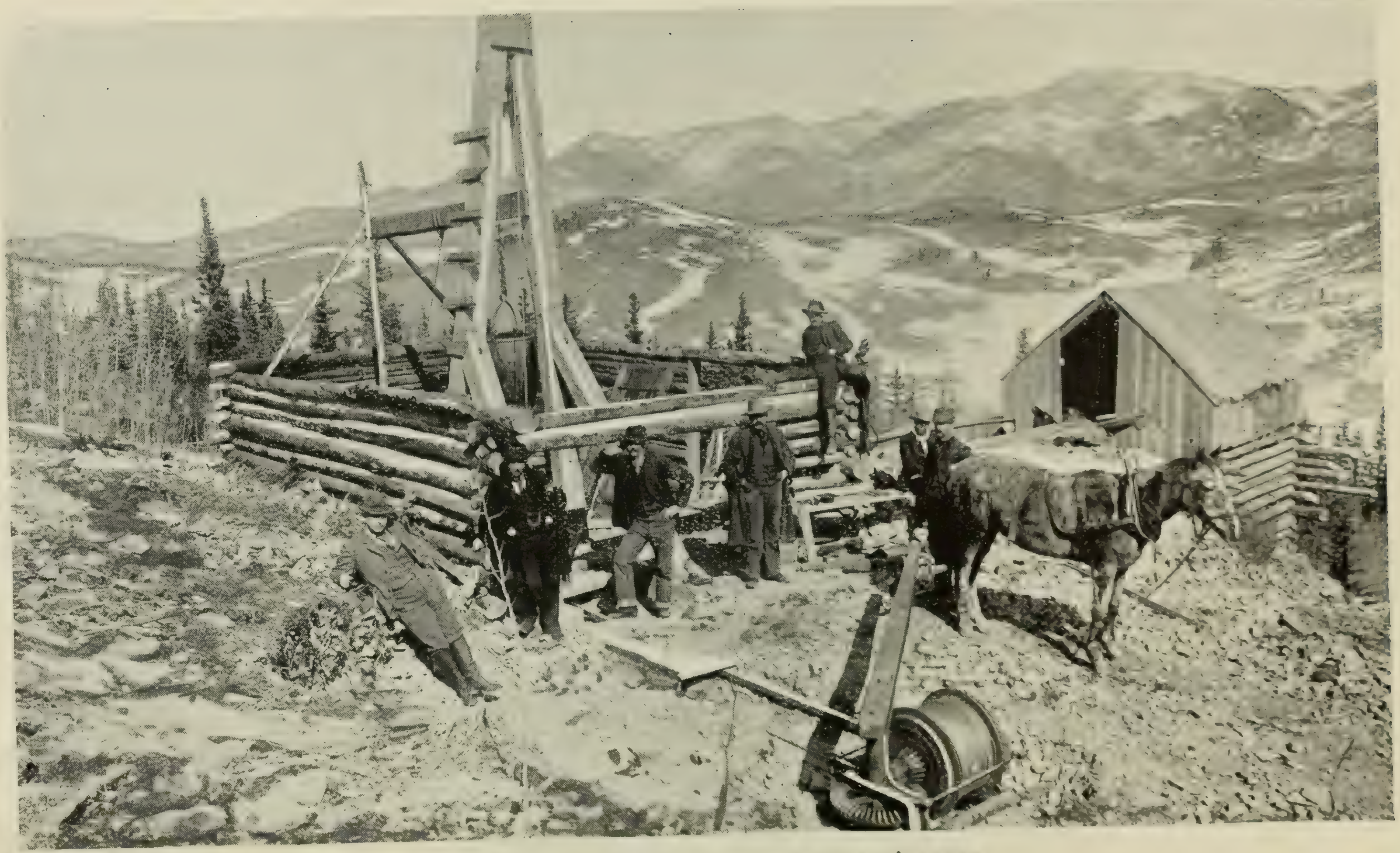

BUENA VISTA MINE AND PIKE'S PEAK, WILSON'S CREEK.

bodies of ore have been found near the surface and developed as open quarries. With depth some of these have greatly diminished, or even temporarily played out. The ore-bodies in few mines are continuous for a great distance. They lie in patches or chutes, often with long intervals of barren rock between.

The width of the vein matter between walls may be from a few inches to several feet, and the pay streak likewise, widening and pinching and temporarily playing out with depth or extension, to be renewed again. In some few mines the so-called vein consists of lava-clay with a remarkably regular vertical cleavage parallel to the walls. The lines of cleavage are filled with iron and manganese stains and quartz containing the ore. This vein-lava often assumes the fineness and hardness of jasper and is called jasper ore. In granite the vein may be simply a decomposed quartzose granite between walls of red granite, with seams of clay and rich sand in free gold. Again, a lava dike may occupy the space between the granite walls, and the ore lie at the contact between the lava and porphyry on one or both sides of the dike. The granite seems the most affected of the two rocks by the ore solutions which have bleached and decomposed it, leaching out some of its constituent minerals, such as mica, and replacing them with metal or with quartz, pyrite, and fluorspar. Black oxid of manganese, iron oxid, fluorspar, and quartz are commonly associated with the precious metal. The quartz is at times milky and opaque, of an opaline character; at others it forms crystalline geodes, the crystals sometimes of an amethystine color. The highest values are commonly in a soft, clayey, sandy "gouge" which, when panned, shows a large amount of bright free gold. The purple fluorspar is sometimes rich, sometimes poor, in gold. The porphyry and wall rock at times is impregnated through its mass with minute iron pyrites which does not, as a rule, carry the highest values. The gold itself may be found free, especially near the surface, associated with iron or quartz. With depth it is seldom free, or visible, but is contained in bright silvery specks of tellurium lining fractures in the rock. This telluride (popularly called sylvanite) is the main gold staple of the camp. When the tellurium is roasted, the gold appears in globules on the rock. This gold is remarkably pure with very little alloy of silver. When free it is generally rusty.

Besides the ore found in veins in the rocks, there is quite a large area that would be valuable placer ground but for the paucity of water in the district. Singularly enough, two mines struck the most powerful bodies of water we now have in the camp, in developing their veins. In one case the flow was so strong and continuous as to supply two or three mills in the gulch below. The water was so charged with arsenic and other mineral salts as to be undrinkable. In the other case, the water which issues from the fissure vein of a mine on top of a hill was found to be quite pure. Despite the lack of water in certain localities the earth has been thrown up in mole-hills, and washed by rockers and other devices, with considerable profit, the water being brought in barrels, or else the dirt carted to distant streams and washed. The placer material consists of small, sub-angular pebbles, mixed with a "black sand" or magnetite. The gold is not much water-worn but angular. Nuggets as high in value as $33 have been found, and men have made from $1 to $5 or $10 per day.

There are in the Cripple Creek camp about thirty shipping mines, of which perhaps a dozen are dividend-paying and a few more self-supporting. The good mines are for the most part very good mines, putting out very rich ore. Others, again, are doing well, with an occasional very rich pocket. In most mines there is to be found, with the rich ore, a good percentage of medium low grade, and some very low grade. Twenty-dollar ore may be considered as medium low grade, and $10 ore as quite low grade, while $5 ore is scarcely reckoned as of any value. This depends upon whether the ore is free-milling, or a telluride and smelting ore. In the former case $5 ore would pay well, while in the latter $20 is as low as is profitable.

The high-grade ore ranges all the way from $75 up into the thousands. Some mines are steadily shipping ore worth $200. The camp at present is rated at a $100 grade, partly because that is the real average grade of many of the mines, and partly because little short of that value is at present shipped, the arrival of the railroads being awaited before the shipment of ore of lower grade. A few statistics will show the general character and value of the camp: The total output for 1893 was about as follows:

15,550 tons smelting ore valued at	$1,840,540
34,348 tons of mill ore	519,300
37 pounds of pure gold from a single mine	11,840
Placer gold	28,000
Cyanide mill product	7,500
Total	$2,407,180

The output for 1892 having been under $600,000, a gain is shown of over 300 per cent. for 1893. But for the labor troubles it was hoped and estimated that the camp would produce some $5,000,000 or more during 1894.

For the first year of the camp's history, it is said, no word of discontent was heard. Men worked nine hours, including a half-hour intermission for dinner, for $3 per day, until the arrival of bodies of Cœur d'Alene miners and professional agitators, who persuaded them that wages ought to be $3 for an eight-hour day. The Cripple Creek miners were receiving the highest wages paid for mining in Colorado, $2.50 to $3 for ten hours' work being the average elsewhere. A large body of the miners having been persuaded to join the miners' union, they became aggressive, refused to work, prevented others from working, and attempted to dictate to mine-owners. The owners, for the most part, declined to be dictated to, and shut down their mines, and the feeling grew bitter on both sides. The union men having the upper hand, the rest had to submit under intimidation, with the result of paralyzing business. It was felt that a crisis was impending and it began to come toward the last of May, when the new railroad, having reached the outskirt town of Victor, brought one hundred well-armed deputies. Their arrival was the signal to the strikers to blow up one of the mines with dynamite. The miners had fortified the hills in every direction, and were well organized and well armed, so that the handfull of deputies would have been powerless to cope with them. The latter, therefore, retired to await reinforcements. A slight skirmish occurred between the deputies and a body of miners, in which two men were killed and several wounded. In June, after demonstrations in force by deputy sheriffs and the militia, a compromise was effected and most of the mines were reopened.

The effect of the strike was for the time being a paralysis of business. Several mines which had been operated on lease, however, were not interfered with by the strikers. Besides many prospects are being developed, some of which doubtless are to become important mines of the future. Despite the strike, the size of the town has nearly doubled since last year. The population in the district now numbers about 10,000. The streets are crowded nightly with employed and unemployed and by a throng of loafers, both professional and enforced. The worst feature of a strike of this kind is not so much in the loss of money and time, as in enforced and long-protracted idleness. One who sees hundreds of men loafing outside the saloons with blear eyes and dilapidated frames, and a general slouchy air, wonders that they could ever have been or could again become industrious, active, bright-eyed miners. It is impossible to walk through a camp in this condition without feeling its depressing atmosphere.

Most of the other new gold-camps in Colorado are so infantile that little can be said of them or of their future. Some of the old camps have become rejuvenated and freshly gilded, and are doing better than they were. Some, generally considered as purely silver camps, have accommodatingly found gold. Not a stream that flows from the great ranges but will pan and show some "color."

The Leadville gold-belt, recently discovered, was credited last November with producing at the rate of $2,000,000 a year. Gilpin county in 1893 produced upwards of $2,000,000; Clear Creek county produced $300,000; Summit, $1,000,000, and Boulder and San Juan about the same. In Park county old workings, both on veins and on placers, have been reopened with profit. In Gunnison county promising gold discoveries have been made on Goose creek and Ohio creek. Silver Cliff, in Custer county, has also swelled the "golden tide." At Creede some of the silver-mines with depth have shown gold. Some fifty small camps have been opened up in twenty counties.

At Leadville the gold-belt passes through Breece hill and Idaho Park and along the Mosquito range for some miles in a general north-and-south direction. The Leadville region is one of porphyry and limestone. At the contact of these rocks, the lead-silver ores have hitherto been found. In somewhat similar contacts gold is now found, associated with silver, also between two porphyries and in fissure veins and impregnations of the porphyries. At Goose creek, Gunnison county, veins occur in a volcanic *breccia* and in granite. The gold is free-milling and is also associated with copper and iron pyrites. On Ohio creek placers are tunneled down to bed-rock, yielding at times from $15 to $30 per ton. In the La Plata mountains, in southwestern Colorado, large placers have been found, panning, it is said, from 50 cents to $1 per pan. These placers have been traced to gold-veins in place on the hillside, the ore of which was low grade but plentiful. In Park county, on Crooked creek, rich gold float has been found.

From the top of Mount Pizgah, a very prominent peak above the town of Cripple Creek, one looks west over a low rolling country composed of lavas and granite, covering many square miles and extending southward to the Arkansas-river cañon and northward to the southern end of the basin of South Park. This volcanic region, after his experience with Cripple Creek, is highly suggestive to the prospector as a likely one. Towards its northwestern limit a small camp called Balfour has been opened on the strength of a few prospect holes, showing moderate assays, and a general mineralized character of the eruptive rock as at Cripple Creek. This may or may not prove, with development, to be a sister of Cripple Creek.

Colorado has no little "grit" in the make-up of its citizens. Driven out at one point, they are up and at it again at another. At one time Colorado was an important cattle-raising state. This business failed, and it became a silver state. This, too, has temporarily failed. Attention was turned to its great coal-fields, clays, building stones, and baser metals, and now it is not improbable that ere long it will be widely known as a gold-producing state.

THE EARLY LIFE OF GREAT INVENTORS.

By Leicester Allen, A. B., M. E.

DIFFERENCES in mental traits as well as differences in disposition manifest themselves very early in life. Two boys playing together will expose the intellectual predilections which are to guide them in the selection of their calling, and influence them through all their future years. One, perhaps, seated studiously in a corner, or on the bank of some mill-pond, will try to fashion a boat out of a shingle or a piece of board, shaping the outline in accordance with the outline of any ship's deck that he may have seen, and providing it with a mast, rudder, bowsprit, and paper sails. But a companion will approach and offer to trade pocket-knives, not intentionally interfering with the pursuits of industry, but giving expression to his strongest propensity. The young shipwright has strongly developed faculties of construction, and may possibly become an inventor in after years. Or he may become a manufacturer merely, availing himself of the inventions of other men and turning them into the channels of profit. But that his companion will become a merchant or trader of some kind will be too probable to need suggesting.

It is a common impression that young men select their callings with a view to the profits that may be gained, and that they become merchants, manufacturers, or professional men with definite ideas in relation to the pecuniary rewards that may follow upon success. But, except in rare cases, it is probable that this is not a true impression. We know that an overwhelming majority of young men choose callings in which there can be no reasonable expectation of fortune, and often they never afterwards cease trying to kick themselves for their thoughtless blunder. Men discover very early in life the need for labor of some kind ; but they are much more likely to select the kind that seems to be congenial to their taste, or more promising to their ambition, than the kind that promises the largest pecuniary rewards. It is doubtful, indeed, if the desire to accumulate wealth is strong enough in any young man just starting in life to give him his direction. A few young men will be heard to say that there is not money enough in this or that occupation to lead them to follow it, but even in such cases it is generally true that lack of predilection rather than very clear eyes looking to results lies at the bottom of their decision. The desire for accumulation comes at a later period, after the romantic ideas of life which possess most young men have given way to the reality, and they have learned to see that the measure of their pecuniary success is generally regarded as the measure of their ability. It is even doubtful if young men ever select a calling with a view to getting rich. Many young men are led into their pursuits by their environment, their adaptability, springing only from hereditary traits at best, and manifesting not even hereditary fitness. These accidents result in placing many square pins in round holes, and many round pins in square holes, but they are only accidents, and, as a rule, the choice of pursuit is inspired by mental organization. What manner of men, then, are the men who become great inventors, and contribute more than any other men to the visible progress of society?

In this field of research we find that the profession of painting has contributed a larger proportional number of the great inventors of the current era than any other pursuit. Notwithstanding the comparatively small number of professional painters extant, we find, indeed, that they have contributed, either directly or indirectly, nearly all the inventions that have given distinctive features to modern civilization. Robert Fulton, the first person to make a commercial success of the various devices for steam navigation that had been conceived, was a portrait-painter, and, as the frontispiece to Webster's "Unabridged Dictionary" testifies, a very good one, too. But his invention not only covered the oceans, rivers, and lakes with steam-vessels, but it suggested the locomotive, and covered the continents with railways. Morse, the inventor, who sent the first telegraphic message over a long line of wire, was a landscape-painter, and was elected and reëlected president of the National Academy of Design during the entire twenty years while he was incubating his idea, mainly to strengthen his resources. But Morse, again, was the parent of still other inventions. The telephone is the direct offspring of the telegraph, and even the electric light, when we consider its appliances for distribution, seems remarkably like a first cousin. Daguerre, the magician who set the sun at work as a journeyman and opened the way for all the refinements of photography, was another landscape-painter, and the man who contributed so much to the pictorial resources of this Magazine by compelling the great luminary to work on metallic sun faces in photo-lithography was still a fourth man among the painters who have been making a mechanical and almost a social revolution. We see, therefore, that there seems to be a very intimate relation between invention and the fine arts.

A peculiar illustration of the way inventors are made is furnished in the life of Eli Whitney, the inventor of the cotton-gin, a man whom Macaulay classified with Peter the Great as an architect of the prosperity of great nations. Whitney was a nail-maker during the revolutionary war, shaping the nails by a hand process; but he was ambitious, and finally got together money enough to enable him to matriculate at Yale. After he was graduated, he went south to fill a place of tutor in a private family. But, finding the position filled, he determined to study law, a decision that would have resulted in placing a round pin in a square hole had he not received a better direction by accident. His constructive faculty had not escaped the observation of a lady in whose house he had been invited to make a home while studying law; and when some visitors were heard to express regret that a better means than hand labor could not be found for ginning cotton, she directed them to Whitney with the assurance that he "could make anything." The result was the cotton-gin, and the conversion of a prospectively commonplace lawyer into a great inventor. But by this invention Whitney realized no share of the great national wealth that he created. Defrauded of the profits of his invention, he was obliged to engage in the manufacture of arms as a means of obtaining fortune that was his due, and his life, therefore, illustrates the adverse fate that often follows the inventor as well as the circumstances by which he is made.

Allusion has been made to a quality of mind that must be possessed alike by artists and inventors, since so many painters have also been inventors. It has also been said that poets are born, not made. The power of imaging in the mind things not present to sense is this common quality shared by painters, poets and inventors, and the great writers of romance as well. When we look for something in the youthful training of inventors for the influence that has given direction to their life-work we shall mostly fail to find what we seek. From the unlearned (that is to say, those who have not received the systematic education afforded in schools), have come the largest number of adepts in invention; but this class has in all ages far outnumbered the scholarly class. In examples soon to be cited as a fair average of early training received by those who have revolutionized arts and industries by invention, some have received collegiate or university education and others have had only the most meager opportunities and gained only the mere rudiments of education from schools. But all have been imaginative, studious men, self-educated to expertness on the lines whither their genius led them, and all possessed that untiring persistence that never yields to temporary discouragements.

Let us begin to draw our examples of such men from the history of the art of printing—the art preservative of all arts—and then, without standing upon our order of going, ramble abroad over the field of invention, to see what start in life some of the boys who, as men, revolutionized industries, arts, and sciences, were able to get.

The names of Andrew Campbell, William A. Bullock, and Richard M. Hoe are inseparably connected with the progress of the art of printing. Each of these men sprung from obscure positions, and each achieved much. Campbell, left an orphan at the age of twelve, worked afterward on a farm ; but his genius led him to mechanical pursuits and, finally, to the invention and manufacture of high-class printing-machines. His ingenuity was no greater than his personal force and decision of character. He once cabled an entire patent specification to English patent agents at a cost of a dollar a word in gold, in order to head off a workman who had started on a steamer for England with a view to anticipate an invention considered valuable, and which the then existing patent law of England permitted the first applicant to obtain. Bullock began life as an iron-founder and machinist, manufacturing hay- and cotton-presses. From these comparatively rude machines it was a long step to his famous printing-press which delivered 30,000 sheets per hour printed on both sides ; but he was equal to that achievement, the effect of which upon the publication and distribution of news was scarcely inferior to that of Edison's improvements in telegraphy. Hoe was the son of an English farmer and started as a boy to learn the trade of joinery. Coming to America, he worked at his trade a little while, and then joined his brother-in-law in the manufacture of a hand printing-press invented by the latter. From this small beginning sprang the great establishment afterward carried on by Mr. Hoe for the manufacture of the mammoth power printing-presses now so extensively used in the great newspaper-offices, and from which sheets are thrown out printed on both sides at a rate almost incredible to those who have not witnessed the operation.

Sir Richard Arkwright, born in poverty at Preston, England, worked from boyhood as a barber and shaved faces until he reached the age of thirty-five, at which period he began to astound the civilized world by a rapid succession of inventions that completely revolutionized the manufacture of textiles. From the introduction of his machines dates an era in the industrial arts. An example of a different character is furnished in the career of Professor Alexander Dallas Bache, a great-grandson of one of the greatest Americans, Benjamin Franklin. Unlike his renowned ancester, Professor Bache had excellent educational advantages. Graduating at the age of nineteen at the head of his class at the West Point Military Academy, he was retained there as professor, and, at the age of thirty, was chosen president of Girard College. Subsequently given charge of the United States coast survey, his improvements in instruments and exactness of methods gained him world-wide fame. He was not only an able scientist ; his fame as such has overshadowed the fact that he was also an accomplished engineer and inventor. Another man of rare genius of whom the public has known much less than of Professor Bache, was Simeon Borden. This inventor and engineer was emphatically a self-made man. After receiving such instruction as was afforded by a district school in his native place (Fall River, Massachusetts, then called Freetown), he mastered the arts of working in wood and metals and the studies of geometry and applied mathematics without other assistance, and qualified himself as a skillful surveyor and mechanician. He performed the first geodetic survey ever executed in America, and its accuracy was confirmed by the subsequent work of the United States coast survey under Professor Bache. He was numbered among the earlier railway constructors, and his life well illustrates what a man with health, determinate purpose, and untiring perseverance can accomplish. He also surveyed and marked the boundary-line between Massachusetts and Rhode Island, which had been previously a subject of much dispute.

Another engineer who made the world respect his talents was James Brindley. Son of a poor and dissolute father, through his own efforts he struggled to the front, and demonstrated that he could drain mines, build mills, and construct canals for internal navigation, becoming, in the latter capacity, famous as a constructing engineer. Issuing from the grime of a coal-mine a poor fireman, rude in manners, uncouth in person, entirely self-taught, George Stephenson gave to the world one of its most wonderful machines—the locomotive. Others who had been privileged with immensely greater advantages—one of them no less than the great John Ericsson—strove to wrest the prize of this achievement from the grasp of the daring innovator; but it remained for history to record that, of all the machines brought forward, his and his only became the parent and progenitor of the modern locomotive. Who shall estimate the effect of this great invention upon the progress of the human race? A son (Robert Stephenson) of the great inventor of the locomotive received an excellent university education and became a famous civil engineer, particularly noted as a constructor of famous bridges. Honor after honor was conferred upon him at home and abroad; yet all these pale in the splendor of the renown which will forever perpetuate the name of George Stephenson.

The invention of the tubular boiler, without which not even Stephenson could have succeeded in making a practical locomotive, is proved by indisputable evidence to be due to Nathan Read, a native of Warren, Worcester county, Massachusetts. Read was educated in Harvard University, directing his attention first toward theology, and afterward toward medicine. After leaving the university he became an apothecary; then he engaged in the manufacture of chain-cables, anchors, etc., in the Salem iron-factory, of which he was one of the founders. He made several inventions, but the most important, the tubular boiler, was not generally adopted until a subsequent period, thus sharing the fate of many inventions that have appeared before the time was ripe for their introduction.

Ephraim Ball, inventor of the "Buckeye" mower and reaper, and the "American" harvester, and other agricultural machinery, began his career at fifteen as a jobbing carpenter's apprentice in Canton, Ohio. He lived to see the great revolution in agricultural operations following the general use of this class of machinery. His early education was extremely meager. Thomas Alvah Edison was launched into the active business of life at the age of twelve as a newsboy on a railway-train. His early education was received from his mother, who was a teacher. Now his name is a household word in all lands as that of one of the greatest inventors this century has produced. Erastus Brigham Bigelow, than whom no American has contributed more (if any as much) to the art of weaving, was the son of a cotton-weaver of West Boylston, Massachusetts. The failure of his father in business curtailed his educational advantages, yet he became singularly prolific and successful in invention and in business, and evinced some skill as a writer upon economic subjects. Smeaton, the foremost civil engineer of his generation, and also a noted inventor, was principally self-educated. He gave evidence at the age of fifteen of rare mechanical ability, subsequently fulfilling his early promise in this regard by numerous improvements in mill-work. Afterward, turning attention to civil engineering, he erected on the site of repeated failures the famous Eddystone lighthouse,—a grander monument of his skill and genius than any sculptor could chisel.

James Watt, the father of steam engineering, was in youth a maker of philosophical instruments; and it was in this capacity that he began his studies of the nature of steam that have crowned his name with honor both as scientist and mechanician. Eli Whitney Blake, inventor of the celebrated stone- and ore-crusher that bears his name, was a graduate of Yale, intending to pursue the legal profession. His uncle Eli Whitney (inventor of the cotton-gin), seduced him from this line of study to give aid in organizing the Whitneyville gun-factory. Here Mr. Blake made important improvements in gun-making machinery, but he will be remembered principally from his invention of the stone-crusher. He was also a forcible writer upon scientific subjects. Jacob Perkins, noted as the inventor of the first practical machine for the manufacture of cut nails and for his improvements in coining and bank-note engraving, was in youth a goldsmith's apprentice. Thomas Blanchard, inventor of machines for making tacks and machines for turning irregular forms such as gun-stocks, shoe-lasts, etc., metamorphosing the trades in which these articles were produced, was brought up as a hand tack-maker. William D. Andrews, inventor of the centrifugal pump so much used in raising sunken vessels and saving cargoes, graduated into engineering and mechanics from a New England country store. He has added many other inventions, the latest and most important being his system of gang tube-wells for supplying water to cities and towns. The brothers J. and W. Hyatt, inventors and introducers of celluloid, were printers before they made their debut as inventors. Corliss, of "Corliss engine" fame, was the son of a country physician, and was educated in the Greenwich (N. Y.) Academy. Alexander Graham Bell, whose name is identified with the telephone, was the son of an Edinburgh teacher of deaf-mutes. He had fine educational opportunities in the Edinburgh University and is renowned not only as an inventor but as scientist.

But it would be superfluous to further extend this list of examples to inclusiveness, and it would be impossible to do so in a magazine article. Were it attempted to include also the names of scientists as well as inventors who have risen from obscurity and even from poverty, surmounting repeated obstacles till their names were written on the glittering scroll of fame, we should find in this list the honored names of Benjamin Franklin, Joseph Henry, Michael Faraday, and a host of others who had not the aid of fortune to help them on their way. And the list would reach back to remote ages that produced an Aristotle, an Archimedes, a Hero, a Euclid.

Enough has been said to prove that inventors are not made by commercial requirements for invention, by education, or the possession of wealth. Any or all of these conditions may exercise either a favorable or an adverse influence, depending upon individual character. And though

> "Full many a flower is born to blush unseen,"

and all inventors do not become great and famous, it is yet as true that inventors are born, not made, as it is of poets and artists. This does not imply that inventors may trust alone to blind inspiration, any more than may poets or artists. Improvement and development of any talent comes only by hard work, whether in school, atelier, library, or laboratory; and all who have achieved anything worth speaking of in this world, have possessed that ability and willingness to work which is the very soul of genius.

THE PREVAILING JEALOUSY OF WEALTH.

By William Nelson Black.

IS this merely a social question suitable only for the contemplation of ideologists, and men who have leisure for the examination of social problems? It involves some very threatening possibilities. The civil or electrical engineer, for example, engaged on some large work undertaken by a man of wealth for purposes of gain, would not think it an irrelevant question among practical men were he invited to an interview some day, and told that a recent rise in stocks, or some unexpectedly fortunate speculation, had brought the fortune of his employer up to the legal limit of accumulation, and that all his employés must be discharged.

But there is no legal limit to accumulation, it may be said. You are supposing an impossible case—setting up a man of straw, in fact—in order to knock him down and show yourself a sociological athlete. This objection would seem to have some force. There is no legal limit to accumulation to-day, but how will it be to-morrow? Do we not hear upon every side, not alone among tramps and men who may be regarded as altogether unsuccessful in the accumulation of wealth, but among men of considerable substance, mutterings about the danger that threatens the community from men of large fortunes? Congressmen who would pass an income-tax law when it is not needed, for the mere purpose of despoiling men of wealth, have not very far to go to begin advocating the confiscation to the State of all incomes that rise above the standard fixed for purposes of taxation. Taxation is the favorite expedient of men who mean confiscation.

The jealousy of wealth will furnish an intensely practical subject for reflection so long as the politician maintains his present importance, and the most ignorant members of the community can control his conduct in their own behalf. We have many laws upon the statute-books through which capital has been hampered in its operations merely for the gratification of the jealousy which is so prevalent at this time; and the chief study of a very large proportion of the men who seek office is to find measures for crippling the capitalist. The precise relations of the man of wealth to the community should be more frequently considered, in order that the men who are willing to serve as breakwaters against ignorance may see its floods diminished as much as possible in volume, and made less irresistible in their flow.

What is the meaning of the words when we speak of the accumulation of wealth? As the process is commonly understood, to accumulate is to gather together something already existing; and hence the popular impression that men get their wealth by taking something out of the hands of other men and appropriating it to their own uses. There could hardly be a greater misconception. The accumulation of wealth by all the honest processes of production, or by buying and selling, is really the *creation* of wealth; the production of something that would absolutely have had no being had it not been for the personal exertions of its creator. Yet this fact is only dimly comprehended by most men who bother their heads with social problems. Sometimes it is not comprehended at all. Men seem to go upon the assumption that there is just so much wealth in the world, and that life is a struggle to see who shall make the largest grab. But as a matter of fact the fortune of every man who earns money by lawful means is simply his part contributed to the total of the national or social wealth.

Take the career of George M. Pullman, just now a conspicuous target for the abuse of addle-headed labor leaders and Populist cranks and "reformers." Starting as a poor boy, through sheer force of inventive genius and masterful business capacity he has amassed an enormous fortune. But every dollar represents new wealth, and no man has ever dared to cast a suspicion upon the character or methods of the man. In fact, William T. Stead, the sensational English editor and reformer, who lately had so much to say in favor of the poor and against the rich and the corrupt elements of Chicago society, when it came to Mr. Pullman found it necessary to say this:

> The first Pullman car which he constructed and put on the rails cost $18,000 to build, as against $4000, which was the price of the ordinary sleeper. Railway-men shrugged their shoulders. It was magnificent, they said, but it was not business. A palace sleeping-car at $18,000 could not possibly pay. Mr. Pullman refused to be discouraged. "Let the traveling public decide," was all he asked; "run your old sleepers and the new ones together; I will charge half a dollar more for a berth in the Pullman and see which holds the field." The verdict of the public was instant and decisive; every one preferred the Pullman at the extra price, and the success of the inventive car-builder was assured. He has gone on step by step, from car to car, until at the present moment he is said to have a fleet, as he calls it, of nearly 2000 sleepers, which are operated by the Pullman Company. They have besides 58 dining-cars and 650 buffet-cars. Altogether the cars which the company operates number 2573. Other competitors have come into the field, but Mr. Pullman deserves the distinction of having placed every railway traveler under an obligation by acting as pioneer of commodious, luxurious, and safe railway traveling.
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> After building his cars in various parts, Mr. Pullman decided finally to centralize in the center of the American continent. Carrying out his decision, he naturally fixed upon Chicago as the site for his works. The Pullman Company was incorporated with a capital of $30,000,000, the quotation for which in the market to-day is twice that amount. He took up an estate of over three thousand acres round Lake Calumet, which is fourteen miles from the center of Chicago, and which was at that time far out-

side the city limits. There, following the example of Messrs. Krupp at Essen, he set to work to construct a model city in his own image. The car-works were, of course, the center and nucleus of all. In these gigantic factories, where 14,000 employés work up 50,000,000 feet of lumber every year, and 85,000 tons of iron, they have a productive capacity of 100 miles of cars per annum. Their annual output, when they are working at full stretch, is 12,500 freight-cars, 313 sleeping-cars, 626 passenger-cars and 939 street-cars.

Now all this enormous accumulation, representing millions in value, affording profitable employment to thousands of people, and conferring grateful comfort upon millions of travelers—all this had no existence when Mr. Pullman began, and it has all been created under his immediate personal direction. To say that his employés did it, or that it would have been done by some one else, is equivalent to saying that Napoleon was not necessary to his work, or that electricity would have reached its present practical development without the aid of Morse and Edison and Bell!

Or take the case of Jay Gould. This much-abused millionaire left a fortune estimated at $70,000,000, the product of a life of great activity in planning and executing works of public utility which continuously employed whole armies of men. But will any man doubt that he contributed the full total of $70,000,000 to the national wealth? Will any man doubt, indeed, that he contributed several times the amount of his own fortune to the total? Consider the wilderness reclaimed, the new towns that have grown into importance along his lines of railway, with their increase in the values of real estate, the manufactures promoted, the contractors enriched, and the various other incidental profits that follow upon the prosecution of great works. Were it said that Jay Gould contributed $500,000,000 to the national wealth during the forty years of his active career the estimate would not be excessive.

What is said of Jay Gould could be said in different terms of Commodore Vanderbilt, whose fortune, now enlarged in the hands of his family, causes so much jealousy. He contributed to the total of wealth vastly more than he secured for himself, and it is reasonable to presume, much more than his entire family of the third generation now holds in its possession. So with many other men of his kind, and in this field of research examples crowd upon us. The Bell Telephone Company, the electric-light companies, and the electric-railway companies, are all very recent representatives of a wealth that would have been non-existent but for the inventive talents and enterprise of their promoters. But even here, too, we must make large estimates for an incidental increase in values. The electric railways are penetrating the suburbs of all our large cities, and by making them more accessible they are adding incalculably to suburban wealth. Yet not a dollar is taken from the public for which an equivalent is not given, either in the form of greater convenience or in actual profits.

Can it be said that these examples are not comprehensive enough to cover the general processes followed in the accumulation of wealth? He would be a man very defective in his powers of observation and analysis who would assert that he could discover any fundamental difference between the operations of the man engaged in railway-building, for example, and the operations of men engaged elsewhere in creating wealth. Wealth is not so objective in some forms as in others, and the processes of creation are more subtile in some fields of economic activity than in others; but the banker, the merchant, the manufacturer, the railway-builder, the contractor, and even that most distrusted of all operators, the speculator, are all subject to a general law of accumulation from which they cannot escape. Even those who seem to work least themselves are yet forced to help keep in motion the machinery of industry, and the result is the creation of new wealth. Except either by inheritance, to which it would be silly to object, or by transactions which, in the evolution of jurisprudence, make candidates for the penitentiary, no man gets possession of more wealth than he creates, and no man can create wealth without contributing to the wealth or income of many other men whom his operations concern. The right, then, of a man to possess all the wealth that he can lawfully obtain cannot be successfully assailed by even the most coherent of the followers of the philosopher who taught that all "property is robbery."

Find the community where there are the fewest beggars, and you will always find the community where the race for fortune is most precipitate. Will there be anything anomalous in this discovery? The mysterious disappearance of the beggar can be easily understood. You have only found the community where labor is most in demand; for the law, which prohibits the acquisition of riches *except through the employment of labor*, is here in full force; and hence the man who would be forced into beggary elsewhere is here enabled to become an honest, industrious, and thrifty citizen. Liverpool, in England, we are told, is swarming with beggars. Apologists for Liverpool will say that this is true only because Liverpool is a seaport town. But other seaport towns are not troubled with a plethora of beggars. The cause of the difference is right here: Liverpool is the one city in the world where disguised but practical socialism is rampant, and where the battle of life seems to have been abandoned; or, if not abandoned, where the retreat from the field is most demoralized and disastrous. From Liverpool we hear of municipal docks, municipal warehouses, municipal railways, municipal tenement-houses, and heaven knows what not of municipal humbuggery. The Liverpool capitalist seems to have gone to Manchester or retired ; and there is nothing left for a beggar to do but to beg. By the time New York comes to her municipal railway she may have as many beggars as Liverpool. It is to be hoped that no member of the New York Chamber of Commerce will be found in their ranks. But the future is uncertain.

The most benevolent institution in the world is the factory that employs one thousand men, unless it is excelled in its benevolent features by the factory that employs two thousand. In the view of benevolent intentions, however, one factory will be just as good as the other, because the proprietor of the smaller factory, if impelled by the proper spirit, will intend to make his employés number two thousand as soon as he can find a market for the work of so many hands.

But the argument from benevolence, like the argument on the title to possession, is so evidently on the side of the man who is endeavoring to get rich that there can be little need for further elaboration. Let us dismiss the benevolent features of money getting, then, and consider such further suggestions as the subject raises, including the suggestion of danger.

If it is both right and benevolent for a man to get as rich as he can, is it not the duty of society, in its own interest, to encourage the pursuit of wealth instead of throwing obstacles in the way? We may be told that there will be no need. The lust for riches is so great that we can always expect an excess of money-getters. This may be true except in the suggestion of excess ; but it is easy to check the growth of accumulation by pandering to that ignorant sentiment that leads to industrial disorders. A strike in a large factory may involve the sacrifice of millions of dollars, and who can say how many of the strikes, which for several years past have been plaguing the country in all its industries, have been due rather to misconceptions of the nature and mission of wealth than to inevitable differences over terms between workmen and their employés, the ostensible reason for strikes. Many labor leaders are sensible men ; but many, also, are influenced by cranks ; and still others are cranks in their own right who cannot be trusted to direct the forces under their control along sensible lines. It will be safe to assume that several hundred millions of dollars are sacrificed by the country each year because a few fools think in their hearts —the only place where they are capable of thinking—that "property is robbery" and that all rich men are robbers.

But all this does not meet the question of danger to the community, a danger which is supposed to threaten from the possession of great wealth concentrated in the hands of a few men. No, for there is no such danger to be discovered by men who take unemotional views of our social environment. In the first place, it is a great error to suppose that wealth is concentrating in the hands of a few men. In 1850, the wealth of the country was something more than $300 per capita. In 1860 it exceeded $500; in 1870 it had risen to more than $700; in 1880 it was over $900; and in the census of 1890 it is reported at over $1000. It should have been more than $1100 by the last census had the preceding ratio of increase been sustained; but strikes having been unusually frequent during the last decade, they have done their work in checking the production of wealth, and we must knock off $100 a head from the total of the national wealth that might have been reached. But an increase from $300 to $1000 in fifty years is remarkable, and it shows that the circle of rich men is continually enlarging relatively to the mass of the community. But the figures may be made to demonstrate it in another way. Were the wealth of which Jay Gould died possessed distributed per capita among the people of the United States, it would give about $1 to each person. Then what a great number of large and considerable fortunes it would take to make up the total increase of $700 per capita in fifty years.

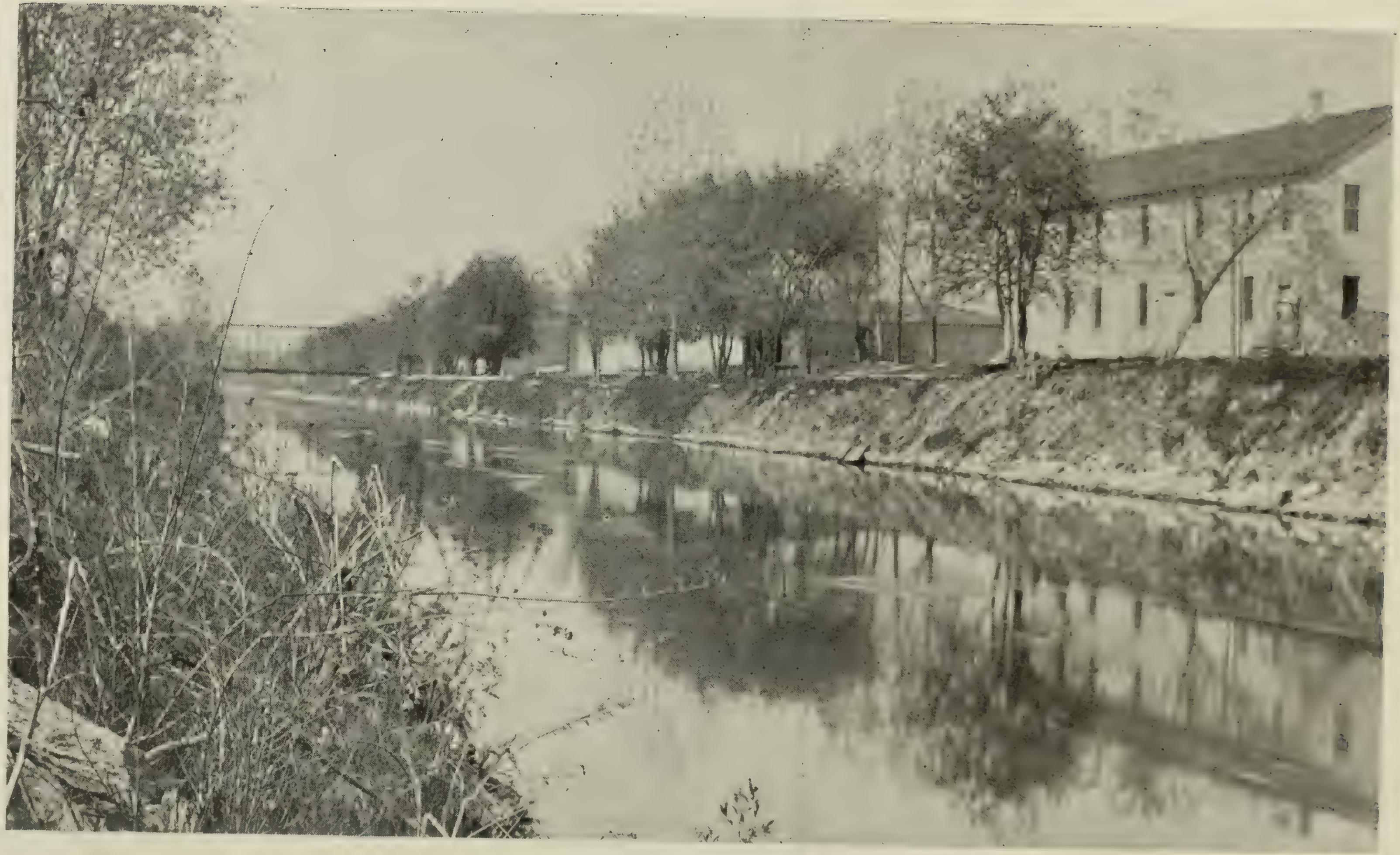
As a matter of fact, the circle of rich men is not only rapidly increasing in numbers, but as it increases the very rich are falling instead of rising in their proportional weight to the community at large. Commodore Vanderbilt could and did turn St. John's Park into a freight station many years ago; but the whole Vanderbilt family could not do a trick of the kind to-day. Their failure, however, would not be due to the fact that the people, as the word is popularly used, have become more influential in the government of the city of New York. It would be due to the fact that there are more men of wealth. It takes the capitalist to fight the capitalist; both like it; and danger only threatens when, like the New York Chamber of Commerce in its recent bout with the elevated railways, they invite the politician to umpire the match. But even were we not protected by the conflicting interests of capital itself, there would be little cause for alarm. Wealth is always on the defensive; and our chief sense of danger is derived from the scarecrows erected by men who are at once jealous, discontented, lazy, and incompetent in the pursuit of wealth.

Instead of being a source of danger, wealth is very dependent and impotent in certain of its relations to the community. The experience of Andrew Carnegie furnishes a case in point. It was only recently that the factory of this great industrial operator, at Homestead, the fruit of a lifetime of intelligently-directed effort, was struck down by his employés; and it took a brigade of soldiers to rehabilitate it and enable him to fill his contracts. Yet his entire fortune that had not been given away for really less benevolent purposes than his industry represented, was invested in this and neighboring factories, and he suddenly became a poor man so far as the productive resources of his wealth was concerned.

So the richest men are rather employers and administrators than proprietors according to the commonly-accepted meaning of the term. They are managing their fortunes for the emolument of men who, through the combined forces of combination and competition, manage to obtain at least 90 per cent. of the product. It has been often said that no matter how rich a man may be he can draw nothing from his fortune except his food and clothing. Granting that his mental appetites and tastes need food for their indulgence, the saying is quite true. No man can draw more from his wealth than sufficient for the personal needs of himself and family ; and all the rest belongs to the community, not in the comprehensive sense in which the State Socialist or burglar might claim it, but in the true sense. The first thing that every man is forced to do when he sets out to make a fortune is to employ somebody to help him ; and the more ambitious he gets the larger and larger becomes the number of his assistants. Some are directly engaged in the promotion of his plans, and draw their compensation directly from his pay-rolls ; but by far the larger number are indirectly engaged, and remain invisible to all except the economic analyst. The wholesale merchant, for example, seems to employ only a few quill-drivers and truckmen ; but his employés are sometimes scattered all over the world, and it is due to his thirst for wealth, and the thirst of other men in kindred pursuits, that these distant employés can find a market for their labor. It will be seen, therefore, that no man can pursue wealth exclusively in his own interest, however selfish he may be ; and when one sees how little there is beyond the reach of men of modest but competent income that the man of large fortune can enjoy, he is led to wonder sometimes at the assiduity of the pursuit. But habit has a great deal to do with it, and the needs and aspirations of a family impel the richest man to further exertion. In this country men rarely retire from business until they die, and it is fortunate for the community that this is true.

It has not been the purpose here to write a panegyric on money-making, however the reasoning may sound to persons who possess their souls in conscious superiority to all such sordid motives. Many men do not pursue fortune as the chief end of life, and prefer to follow callings that directly gratify their intellectual sympathies or tastes. Others, again, who seek money as a first inducement, compromise with their sympathies and select pursuits from which one of the colossal fortunes of the world cannot be expected. But these are examples which cast no reflection on the men who wish to become as rich as

Vanderbilt, or richer. From the material point of view these men are the most useful members of the community, and the man is either a public enemy, a fool, or both, who seeks to obstruct their operations. The writer could not write, the painter could not paint, and the laborer would literally be forced to go fishing were it not for the forces which the wealth-seekers put in operation. The very genius of progress, under the free institutions that we enjoy, rests upon the principle of great rewards to those who accomplish great works; and whatever else may be wrong in our social and economic system, we can not afford to discourage, much less dispense with, the great "captains of industry" who marshal the forces of labor and lead us on toward the golden age that will see the race emancipated from poverty.



VIEW OF THE OLD ILLINOIS AND MICHIGAN CANAL.

THE CHIGAGO DRAINAGE CHANNEL AND WATERWAY.

By G. P. Brown.

ANY work which Chicago may undertake for a long time to come must have more than ordinary proportions not to be dwarfed by comparison with the stupendous and artistic creation at Jackson Park. But before the completion of the World's Fair buildings the city had made a beginning of another work which, at any other time, would have attracted universal attention.

Chicago has long been troubled by a contamination of its water-supply, due to an irrational method of disposing of its sewage. The water-supply obtained from Lake Michigan, in its natural state, is as wholesome as that of any other large city in the world. Indeed, it is claimed for the unpolluted lake-water that it surpasses in purity that of all other large supplies. When Chicago's sewerage system was planned there was no apprehension of evil effects from discharging the sewage into the lake. But the city grew more rapidly than its founders anticipated and sewage and water-supply soon mingled. Temporary relief was obtained from time to time by extending the supply-tunnels farther out under the lake, the last tunnel constructed being four miles long, but in spite of these extensions sewage often reached the inlets, and epidemics of disease resulted.

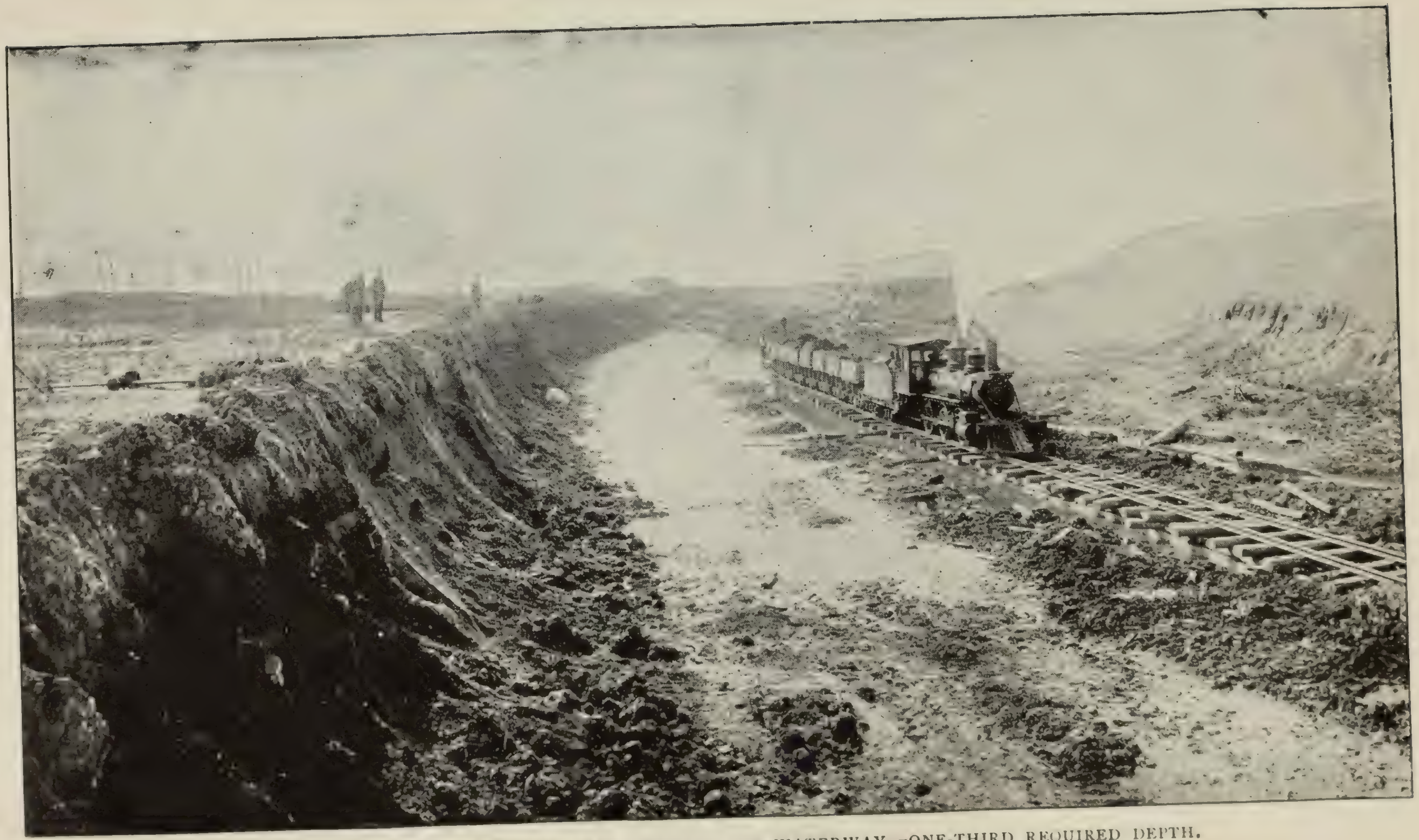
For a long time different plans were discussed for the disposal of the sewage or the introduction of water from other sources. Pumps were constructed at the head of the Illinois and Michigan canal and much of the sewage was lifted into this canal and sent down the valleys of the Desplaines and Illinois rivers. But the canal and the pumps were inadequate to the necessities of the case. Besides, the people living in the valleys objected very justly to having undiluted, or imperfectly diluted, sewage flow past their very doors. Years of discussion and investigation have led at last to the adoption of a plan which involves the partial restoration of a former outlet of Lake Michigan and which, it is hoped, will give Chicago a thoroughly satisfactory means for the disposal of its sewage. This new channel, now in process of construction, will extend from the south branch of the Chicago river to Lake Joliet, a distance of thirty-six miles. It will be cut so deep that the current of the Chicago river will be turned backward, and, with the sewage which it will discharge into the channel, there will be an abundant supply of pure water from the lake. It is as-

ONE OF THE METHODS OF EXCAVATING EARTH.

sumed that the sewage, by reason of the large dilution, will be rendered innocuous before it reaches Joliet. At that point it will be discharged into the Desplaines river, which, by its confluence with the Kankakee a few miles below Joliet, forms the Illinois, the latter emptying into the Mississippi.

More is contemplated than the construction of a mere sewage-outlet. In fact, the people living in the interior of Illinois state would not consent to the construction of a drainage channel until Chicago agreed to build one that would also be serviceable as a waterway. The double object of adequate dilution of the sewage and of navigation was thus secured. To fit the channel for its double object, the narrowest part is to be 160 feet wide and the depth throughout sufficient for the passage of vessels drawing not less than eighteen feet of water. For a distance of about twelve miles the cutting is through solid rock. The walls here are perpendicular and the depth from the surface of the earth from thirty to thirty-five feet. The channel will pass not less than 600,000 cubic feet of water per minute at a velocity not exceeding three miles an hour. The greater part of the proposed work is in the hands of contractors, with the stipulation that it shall be completed in 1896. The total cost has been estimated at $25,000,000.

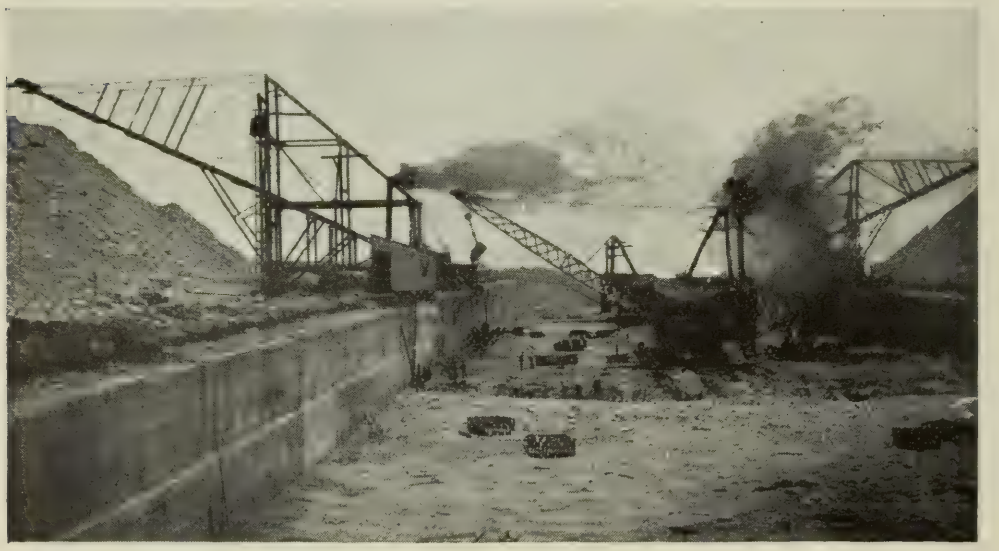
The physical conditions which make this artificial channel possible are of interest. The configuration of the earth's surface in the vicinity of Chicago indicates that the outlet of the great lakes was once to the westward. A river two miles wide and 150 feet deep once swept through a valley which was hewn out of solid rock between the site of



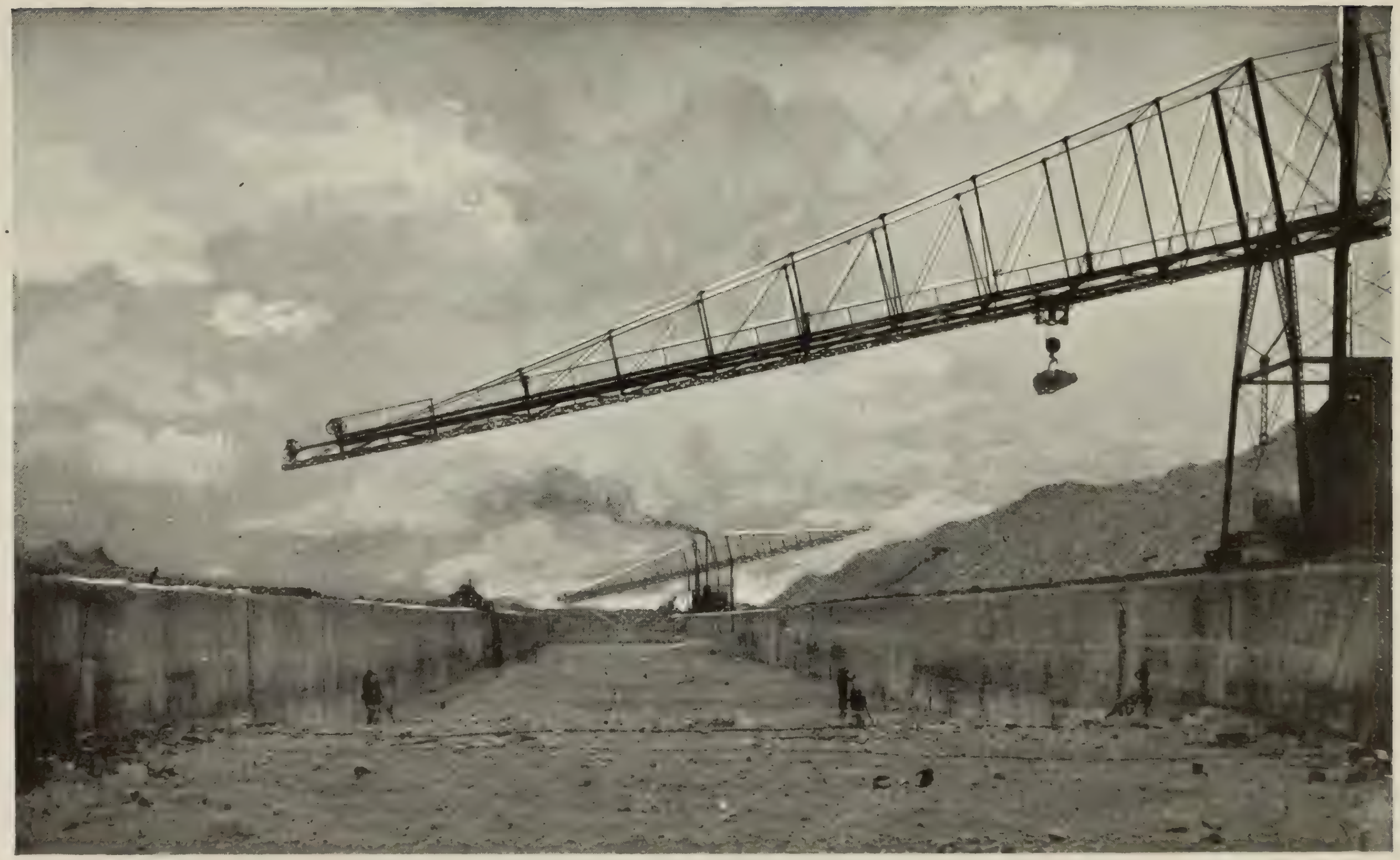
EXCAVATING IN EARTH FOR DRAINAGE CHANNEL AND WATERWAY—ONE-THIRD REQUIRED DEPTH.

Chicago and that of Joliet. Nature may cover up the evidences of her prehistoric operations, but she does not obliterate them. A cross-section of this former outlet is like that of a giant trough. Its outlines are clearly marked and the grooves worn in the rock by the swiftly-flowing stream—aided, perhaps, by ice and glacial débris—are plainly visible. As the waters in the great North American basin were drawn down by the two outlets, one to the east and the other to the west, the rocky barrier in the path of the latter at length resisted the diminishing force of the corrosion, and the surface of the lakes fell below the bed of the western stream. The St. Lawrence thus became the sole permanent outlet for these inland seas.

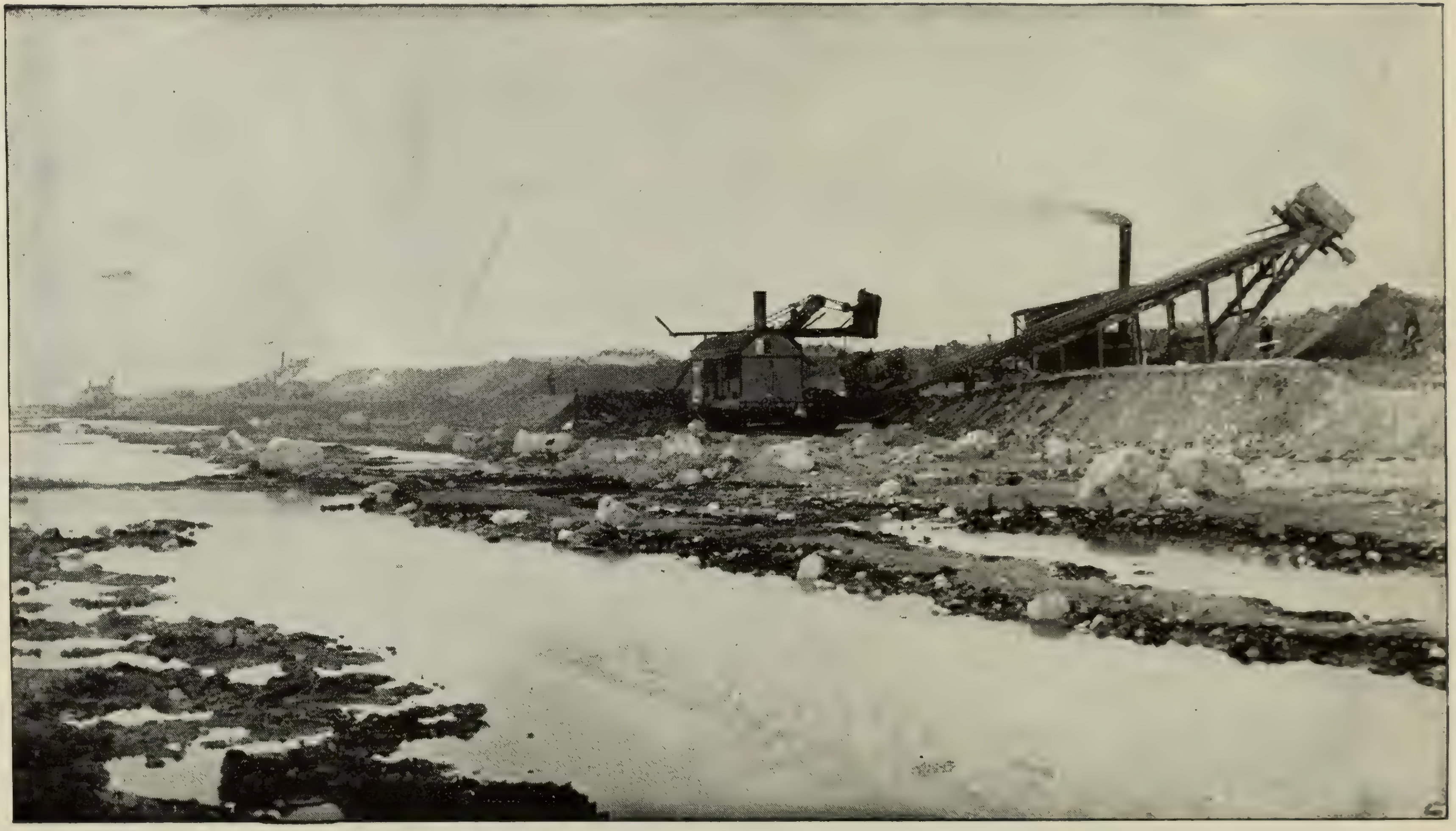
Chicago stands at the summit of the watershed which separates the basins of the two river systems of the St. Lawrence and the Mississippi. Within the boundaries of the city there can still be traced the bed of a shallow lake, two miles long and half as wide. Its site is the extreme summit of the watershed. In times of drought, within the recollection of the present generation, Le Petit Lac, as the early French traders called this shifting body of water, became first a stagnant pond and then a stretch of wet prairie. In floods its waters divided at the middle. One half started on its long journey to the sea by way of the chain of greater lakes and the St. Lawrence, and the other sought a universal level in the Gulf of Mexico. The Chicago river was the immediate outlet of this summit lake at its eastern extremity and the Desplaines river at its western. The former reached Lake Michigan in a flow of less than a dozen miles. The latter crept over the level bed of the ancient outlet a distance of twenty miles and then descended to meet the Kankakee. The Illinois, formed by the junction of the



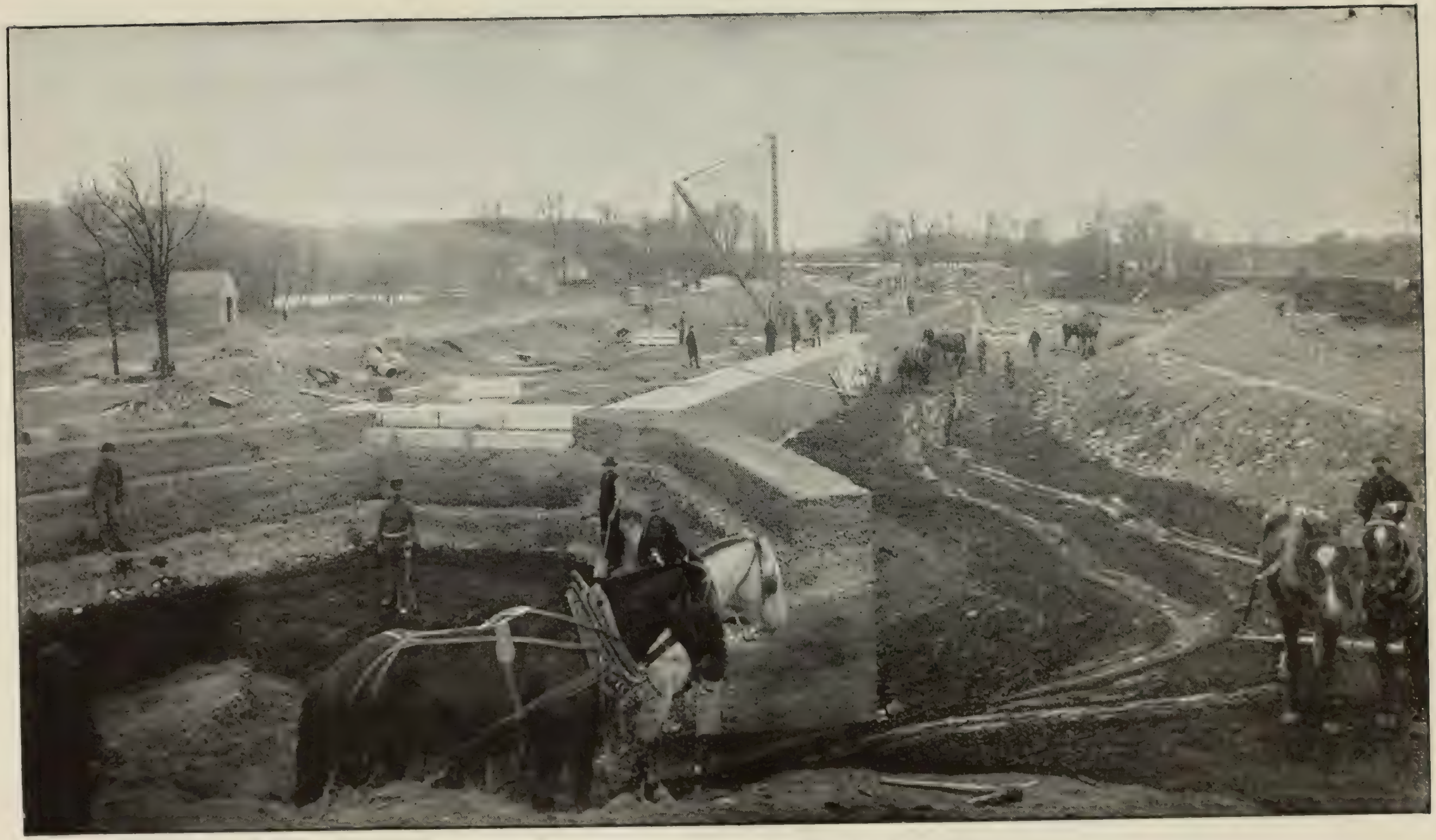
EXCAVATING IN THE SOLID ROCK.



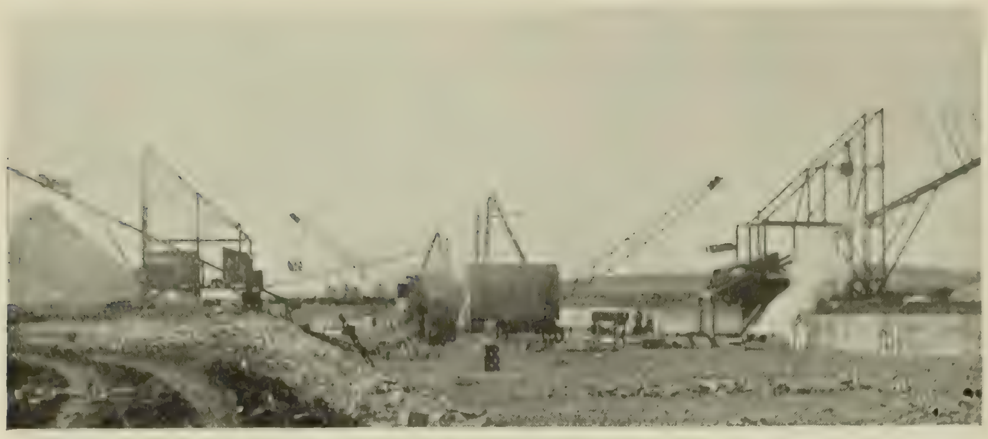
OPERATION OF THE CANTILEVER CRANE.



NEW CHANNEL FOR THE DIVERSION OF THE DESPLAINES RIVER.



DESPLAINES RIVER SPILLWAY, NORTH OF SUMMIT.

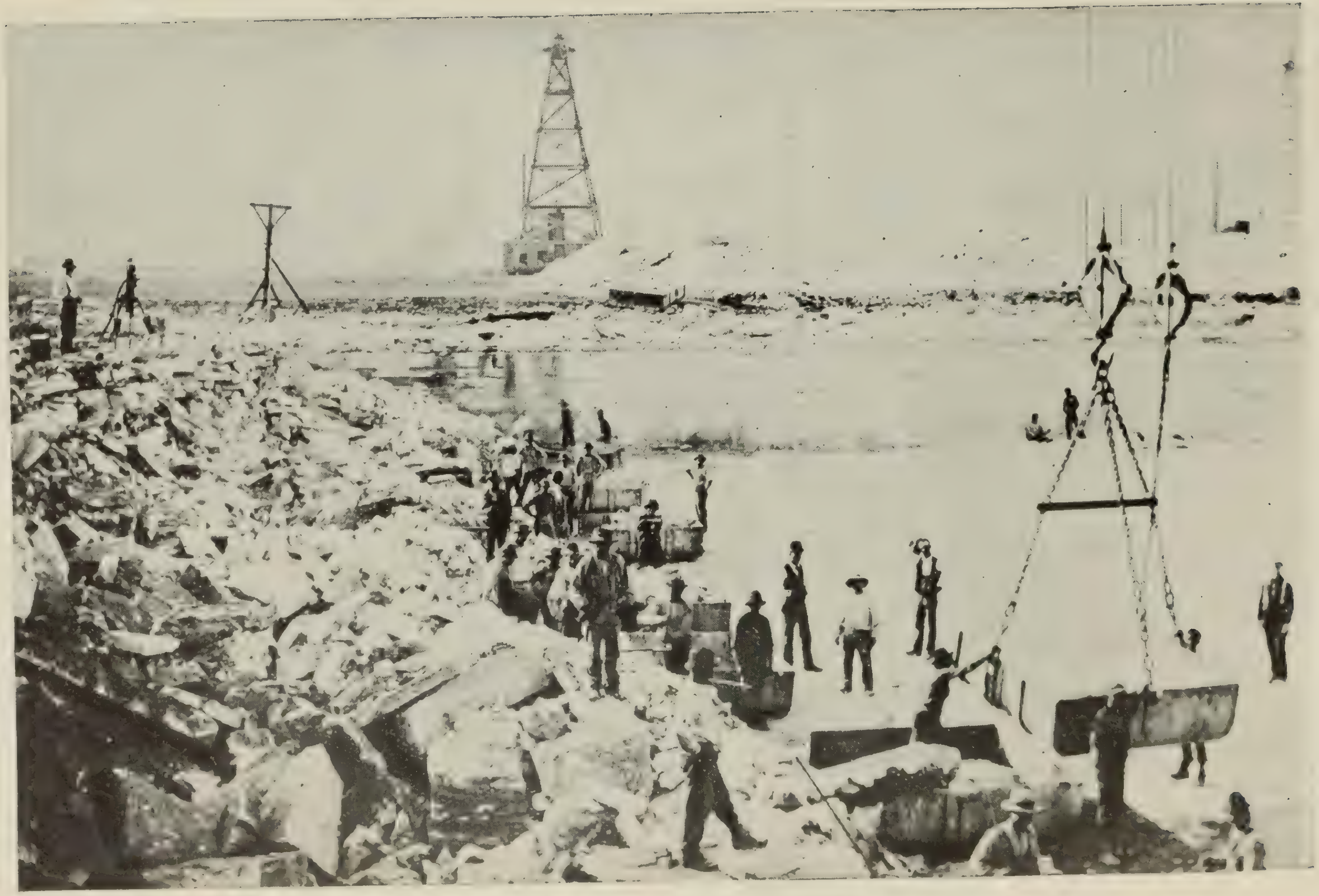


SYSTEM USED ON SECTION 9 OF THE DRAINAGE CHANNEL—TWO DERRICKS AND TWO CONVEYORS.

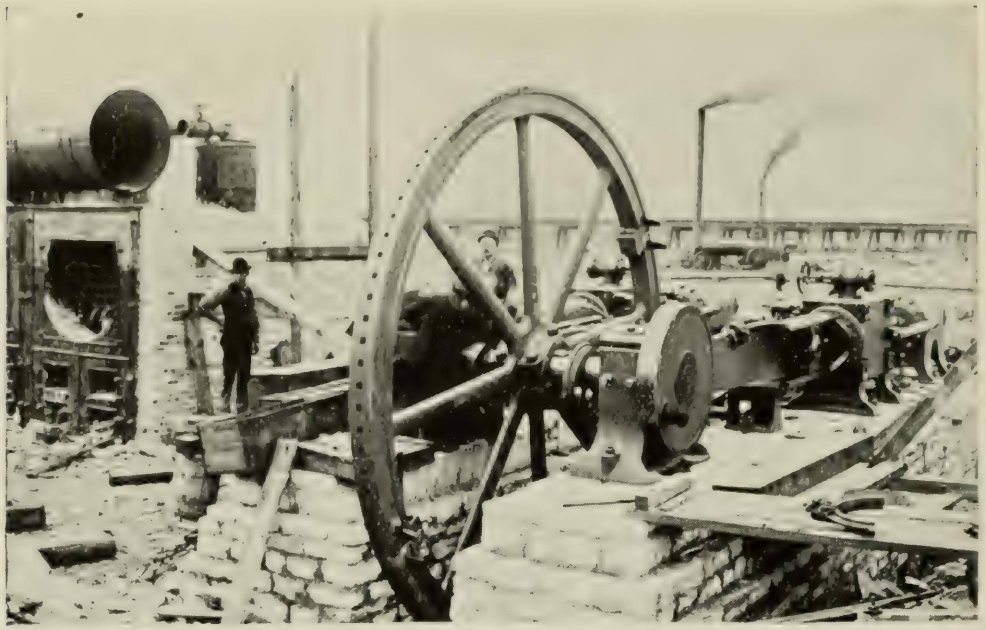
Desplaines and the Kankakee, dragged its course lazily through the alluvial deposits in the valley of the ancient stream, and lost its identity in the Mississippi at the present site of Grafton, Illinois—320 miles from Lake Michigan.

At the time of the advent of white men it was thought that a permanent waterway between the great lakes and the Mississippi could be effected by cutting a channel through the bed of the then partially-extinct summit lake, connecting the Chicago river with the Desplaines. Joliet, who with Marquette discovered the valley of the Desplaines in 1673, was impressed with the apparent practicability of such an undertaking, and he is reported to have said: "We can quite easily go to Florida in boats, and by a very good navigation. There would be but one canal to make, by cutting only one-half a league of prairie, to pass from the

ROCK-DRILLING ON THE DRAINAGE CHANNEL.



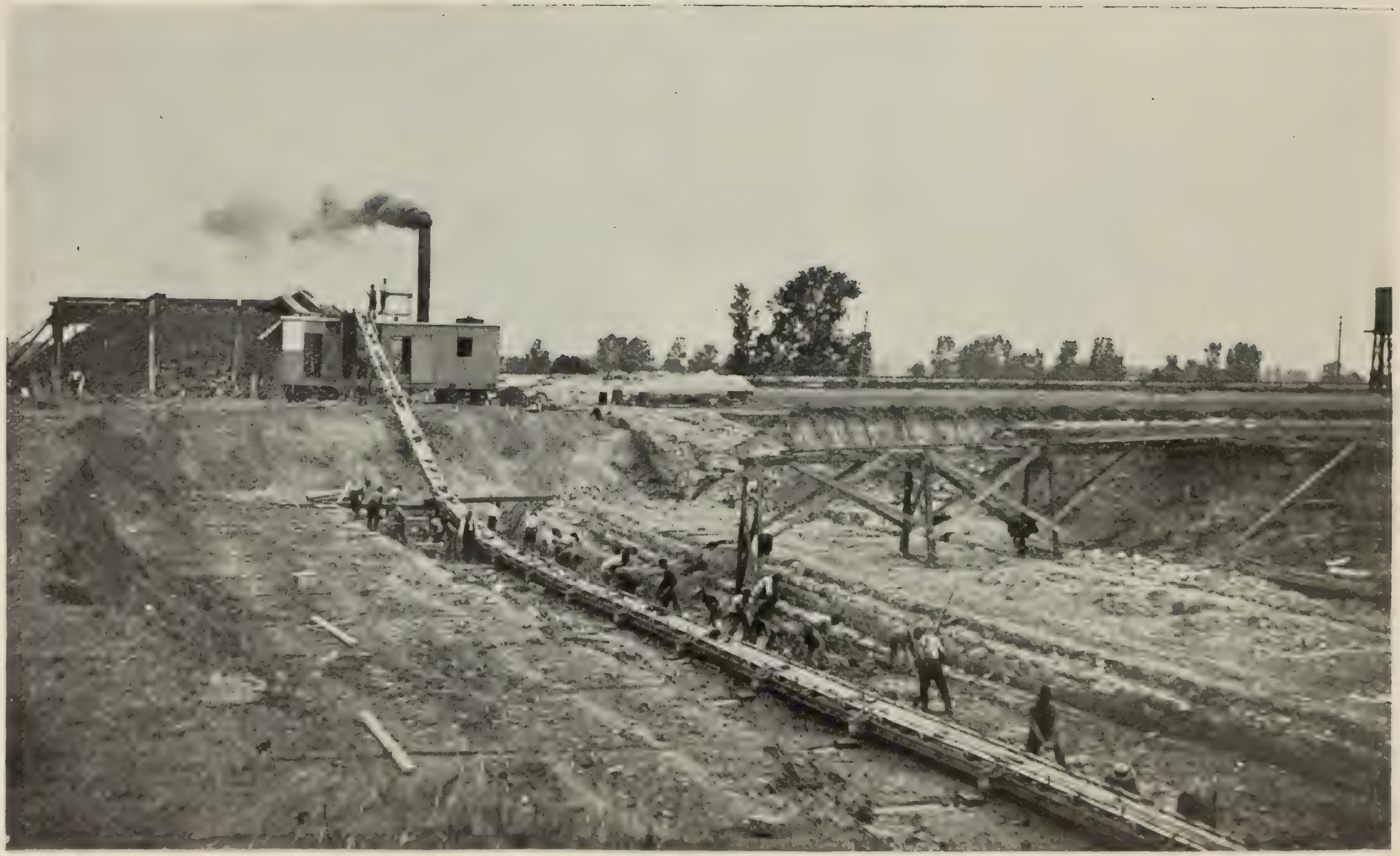
THE USE OF THE LIDGERWOOD HOIST.



COMPRESSOR PLANT USED ON SECTION 8, DRAINAGE CHANNEL.

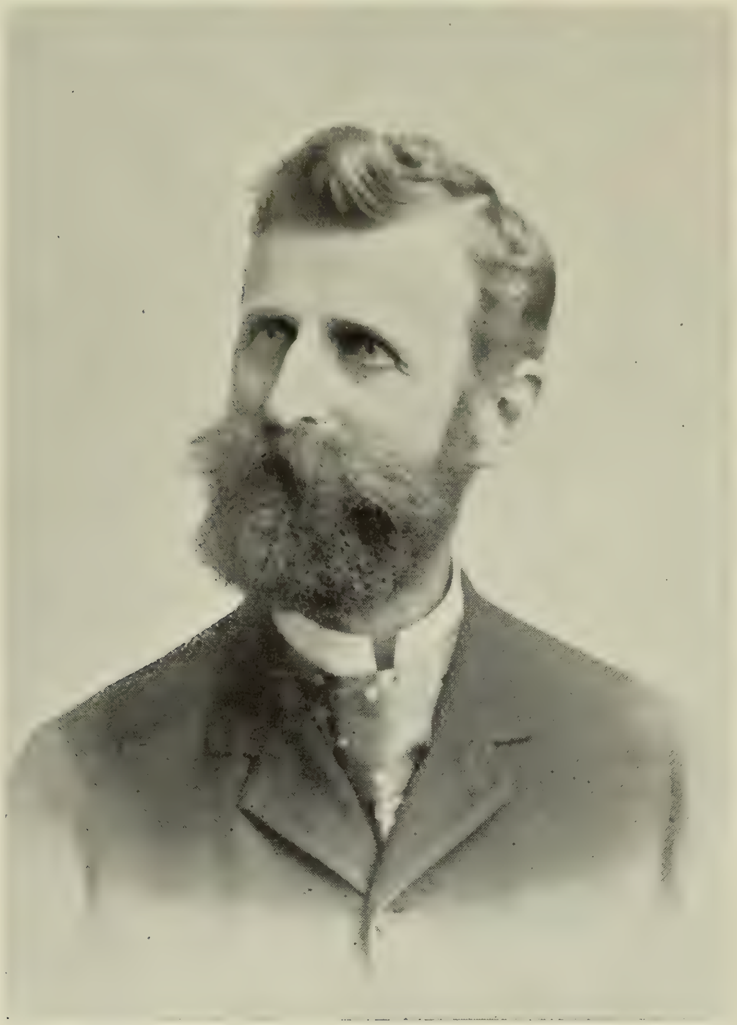
Lake of Illinois (Lake Michigan) into St. Louis river (the Desplaines)." It has since been the dream of many an enthusiast that a navigable stream could again be made to flow through this natural channel to the Mississippi. Practical men have thought that they could see in it commercial advantages which would benefit the entire coun-

HYDRAULIC DREDGE ON SECTION 6 OF THE DRAINAGE CHANNEL, IN 15 TO 20 FEET OF SOFT MATERIAL.



REMOVING EXCAVATED MATERIAL BY MEANS OF A BELT.

try. The question has been earnestly advocated for more than a hundred years. The importance of a serviceable waterway was recognized in a treaty made with the Indians in 1795, when the latter agreed to afford " free passage by land and by water.......from the mouth of the Chikago to the commencement of the portage between that river and the Illinois and down the Illinois river to the Mississippi." The subject was brought before congress in 1804 and has occupied the attention of that body many times since.



ISHAM RANDOLPH

[Chief Engineer Chicago Drainage Channel and Waterway.]

It was soon found that the short cut through the narrow portage which separated the Chicago river from the Desplaines would be insufficient. The first examination by engineers revealed the fact that the bed of the Desplaines was the solid rock of the ancient river-bottom and that it was seven to ten feet higher than the surface of Lake Michigan, the latter being subject to irregular fluctuations. Furthermore, this rock was found to extend through the greater part of the distance between the summit lake and Lockport, twenty miles farther west. The difficulties in the way of the construction of an artificial channel which should have real value were thus increased immensely. But the engineers reported the work practicable.

The estimated cost of construction varied according to the skill and temperament of the engineers. One found that it would be less than $1,000,000. Five millions was believed to be an extravagant estimate. Beyond the rock formation little was believed to be necessary except to dredge the Desplaines and Illinois rivers, with which the artificial channel would connect.

With the aid of a grant by the United States government of every alternate section of land along the route of the proposed canal, the state of Illinois, in 1836, after thirteen years of preparation, began its construction. Its width was to be sixty feet and the depth of water six feet. It was expected that the waters of Lake Michigan would flow through the canal by gravity. But it was afterward found that this would require a cut through the solid rock fifteen to eighteen feet deep. After spending nearly $5,000,000, with a prospect of bankrupting the state, the deep cut was abandoned and the canal completed on a higher level. Water was supplied by pumps erected at the junction of the canal and the Chicago river. The artificial construction was continued to La Salle, a hundred miles from Chicago, where connection was made with the Illinois river. The canal was completed in 1848, at a cost to the state of $6,569,000.24. It was deepened across the ‘‘ Divide ’’ in 1871 sufficiently to create a gravity flow from Lake Michigan. The latter work was executed by the city of Chicago to secure the advantages of drainage, and cost $3,300,883.71, making the total expenditure in the construction of the canal nearly $10,000,000.

For a few years the Illinois and Michigan canal served well both commercial and drainage purposes. Both state and city were benefited. When the canal was begun, in 1836, the population of Chicago was only 3820. The sale at a low price of the lands contributed by the general government and the commercial advantages which the canal promised attracted settlers from the east, so that, in 1848, when the work was completed, the city's population had increased to 20,023. Five years later it was more than 60,000. The population of Illinois state doubled in the ten years from 1830 to 1840.

Within a few years after the deepening of the canal it became necessary again to resort to the use of pumps at the head of the channel. The growth of the city had so increased the amount of sewage discharged into the Chicago river that the latter became unendurably foul. The canal was still too shallow to draw off the water of the river rapidly enough to keep it clean. These pumps were put in operation in 1884 and raised 60,000 cubic feet of water per minute from the river into the canal. The relief was still inadequate, owing to the remarkable growth of the city. The river soon became worse than ever.

It remained, as it had been for thirty years, Chicago's one great curse. It was a perpetual theme for preacher and editor. The people held indignation meetings and stormed over an evil whose radical cure they were unwilling to undertake. Finally, in 1886, the city council authorized the mayor to appoint a Drainage and Water-Supply Commission, to be charged with the duty of devising a plan for permanent relief, and Rudolph Hering was placed at the head of the commission. After an expenditure of $65,000 the commission was disbanded, having completed only the preliminary work.

But two facts at least had been established. The sewage of the city could not be safely turned into Lake Michigan if the water-supply were derived from the same source, and it could not be disposed of on land without enormous expense, although there were thousands of acres of barren land in the immediate vicinity. Chemical treatment of the sewage was also found to be impracticable. Without having worked out the details the commission came to the conclusion that Chicago's sewage must be discharged into the Mississippi river through the valleys of the Desplaines and Illinois. But it should first be so diluted that it would not be an offense to the people living in the interior of the state.

There was good reason for an expression of respect for the rights of others. As the sewage drifted lazily down the canal, scarcely attenuated by dilution, it passed directly through Joliet, a city of 25,000 inhabitants, and other towns of smaller size. The gases set free by its decomposition were the cause of considerable sickness. The offensive odors could be traced as far as Peoria, 120 miles from Chicago. The growth of intervening towns was checked, and some of them would have been depopulated. All were fairly ready to take up arms against the metropolis of the state. They had the sympathy of the whole state outside of Cook county. An appeal was finally made to the legislature for redress. This appeal, fortified by the urgent demand of many of the citizens of Chicago for authority to adopt a suitable remedy, led to legislation in 1889 which provided for the construction of a combined drainage channel and waterway between Chicago and Joliet. At the latter point, it was assumed, the Desplaines river would be able to receive the water brought down to it until plans were perfected for the continuance of the navigable channel to the Mississippi.

Such was the origin of the channel which Chicago is now constructing. As a waterway it will provide an easy passage for the largest of lake-steamers and river-steamboats. Ships of the sea will be able to navigate it when access is provided. It will be as large as the largest of modern canals. It is not likely to cost as much as the Manchester ship-canal, but it will rank with that undertaking in commercial importance.

It is a corollary of the legislation by the state of Illinois that the United States government will continue the enlarged channel from Joliet to the Mississippi by improving the Illinois river. It is supposed that the government will be easily persuaded to complete the work, because of the fact that millions of dollars have been wholly wasted already in attempting to improve that river by a system of slack-water construction. After twenty years of such effort the river is in a more impassable condition than ever. The national government has been urged by the state to stop work of this kind, tear out the dams already built, and create a channel by dredging comparable with the one Chicago is now constructing. When that is done the latter will be turned over to the United States, the continuous channel from Lake Michigan to the Mississippi to become a free waterway.

As a drainage outlet the new channel will insure for Chicago a continuance of its low death-rate. The city will possess an unrivalled water-supply, and a drainage system superior to that of any other large city in the world. When the current of the Chicago river has been turned permanently backward and is fed by a constant flow of water from the lake, that offending receptacle of concentrated filth will become, by comparison, "a clear, sparkling stream," such as a visitor found it in 1833 when the village of Chicago was just emerging from the chrysalis of a trading-post. It has been shown that sewage is rendered practically harmless after a few hours' gentle flow. The people living in the valleys below will hardly have reason to complain of the ill effects and annoyances of the sewage in its new condition.

To construct the enlarged channel the legislature authorized the creation of a distinct municipality, to be known as the Sanitary District of Chicago. Chicago had reached the limit of taxation under its charter and could not itself incur the expense. By this technical evasion the municipality was made to include the greater part of Chicago and such adjoining territory as might be necessary to the execution of the drainage scheme. Its extent is about 185 square miles. The $25,000,000 necessary for the execution of the work is intended to be raised by taxation and the sale of bonds.

The length of the channel from the Chicago river with which it connects at Bridgeport, Chicago, to Lake Joliet, a deep pool just below Joliet, is thirty-six miles. Plans have been completed and adopted for all except seven miles at the Joliet end. This stretch includes the declivity between Lockport and Joliet and the route through the city of Joliet. Contracts have been let for about twenty-six miles, and the work has so far progressed on some of the sections that it could be completed within a year. There had been paid for construction to March 1, 1894, $2,688,097.84, and for land for right of way, $1,949,198.89. It is estimated that the additional land needed for right of way will cost $1,000,000, and the construction at the Joliet end $1,000,000. The estimated cost of bridges, etc., is $1,000,000. The face amount of the contracts let, based on the estimates, is $16,052,686.82. The estimated face of two contracts yet to be awarded is $638,183, making a total of something less than $22,000,000 as the cost of the completed channel from Bridgeport to Lake Joliet. The remaining $3,000,000 which will be available will be needed in perfecting the communication with Lake Michigan at the eastern end.

In the construction of the twenty-six miles of channel now under contract it is estimated that the glacial drift to be removed will amount to 25,621,489 cubic yards and the solid rock to 10,808,353 cubic yards. There will be needed 276,526 cubic yards of retaining-walls. The prices for which contractors have undertaken excavation in glacial drift range from 20 to 30¼ cents per cubic yard, and in solid rock from 73 to 86 cents per cubic yard. By the use of the latest improved machinery contractors appear to find a good profit even at these unusually low prices, and are able to push the work with unexampled rapidity. By the use of such machinery the number of men needed is greatly reduced, but it is expected that not less than 10,000 will be engaged upon the works of the sanitary district during the present summer.

Chief Engineer Randolph, of the sanitary district, recently prepared a statement concerning the work, in which he says :

> It is expected that the channel will form a much-needed extension of the harbor facilities of the city, and be adequate for any future development of lake navigation or deep-water connection with the Atlantic ocean. To this end the channel may be readily widened in the earth and the right of way will be sufficient for any such development. The effect of the large volume of water in the Illinois river will be to give an effective river navigation throughout the 227 miles of the lower Illinois, without obstructing locks and dams, sufficient for the largest classes of Mississippi-river steamboats from the Mississippi to Utica, with very slight improvement on some of the north bars. Thus the first result will be to bring lake and river navigation within sixty miles of each other, whereas they are now practically 320 miles apart. It is estimated that an expenditure of about $6,000,000 will provide fourteen feet of water below Utica in a channel over 300 feet wide. No works have been projected for the intermediate section between the end of the main drainage channel and Utica, over which a descent of some 140 feet must be provided for by means of locks. The consideration given the matter warrants an estimate not exceeding $15,000,000 for a navigation of fourteen feet. It will be seen, therefore, that the expenditure now contemplated by the sanitary district, especially when the channel through the city is provided for, is much larger than that required to complete the work to the Mississippi. In other words, the cost of the first forty miles is greater than the next 280 miles. With the improvements now in progress by the Mississippi river commission, it is anticipated that boats of a draft of fourteen feet will be able to reach the gulf for over

seven months of each year, or for a period longer than lake navigation is open via the straits of Mackinaw, and that the route will be closed by ice for an average of seventy days only. Since 1887 the route would have been open throughout the winter for five years out of six. The state policy underlying the legislation evidently contemplates that the entire project in its larger purposes shall be carried out by the coöperation of the sanitary district, the state, and the nation. It is a part of the policy of the [drainage] board to enlist these forces in proper time.

In the organization of the work a department of health was created. The sanitary inspector, its chief officer, is empowered to enforce rules regulating overcrowding in the camps, ventilation, the use of good food and wholesome water, and the disposal of waste. A hospital service with headquarters at Lemont—midway between the two extremities of the channel—cares for the sick and injured. There has been an entire absence of epidemics thus far, and few serious injuries. To insure order among the workmen, and for the protection of the work in progress, a police department was also organized. Several police-stations were built along the line of the canal and the entire right of way of the sanitary district is patrolled night and day. The affairs of the sanitary district are in the hands of nine trustees who are elected by the people and hold office for five years. They are paid salaries of $3000 a year, the president receiving $1000 additional. The members of the present board are successful business men, or men of established reputation in the professions. They find it necessary to devote nearly all their time to the affairs of the district.

Several changes have been made in the office of chief engineer since the organization of the first board. The first incumbent was Lyman E. Cooley, who was afterward elected a trustee of the district and is now a member of the board. He was succeeded by W. E. Worthen of New York, who was succeeded in turn by S. G. Artingstall, Benezette Williams, and Isham Randolph, the last being the present incumbent. General John Newton, of New York, was consulting-engineer during the incumbency of Mr. Worthen.

The most serious of the unsettled problems with which the board of trustees has to deal involves an adequate connection between the channel and Lake Michigan. The Chicago river, with which it communicates at Bridgeport, is narrow, shallow, and tortuous. Navigation through it is impeded by bridges. It cannot supply more than 300,000 cubic feet of water per minute, one half the required capacity of the drainage channel, without creating a current that would render navigation impracticable, if not impossible. The river cannot be widened without enormous expense, since the shore-lines are built up to the water's edge.

The distance from the eastern extremity of the channel to the lake in a direct line is about three miles. An extension along this line seems prohibitory on account of the great value of the property through which it would run and because of the network of railroads which intervenes. Such an extension would also cut off the entire southern part of the city from the central business district. An irregular, circuitous route to the southward, striking the lake in the vicinity of Eighty-seventh street, the southern boundary of the sanitary district, is the only reasonable alternative yet suggested. Such an extension of the channel would afford drainage for the so-called Calumet region—the Calumet-river basin—for which no provision has yet been made.

Before work on the main channel was undertaken it was necessary to divert the Desplaines river to a new bed throughout a greater portion of the distance between Summit and Lockport. This work was of considerable magnitude. In floods the Desplaines has always overflowed into the Chicago river and helped to drive the city's sewage into the lake. Its waters are now entirely under control.

ELECTRICITY DIRECT FROM COAL.

THE GREATEST PROBLEM IN ELECTROCHEMISTRY.

By Dr. William Ostwald.[*]

THE ground on which applied and abstract electrical science are soonest likely to unite for joint work is that province in which all of us expect to see the next great phase of the application of electrics to technical problems: the province of electrochemistry. The auspices for such a union are uncommonly favorable at the present time. That problem of a hundred years' standing, "the Voltaic pile," has just been solved. By our newly-acquired knowledge of some constants we can now predetermine and very closely approximate the electromotive force of any pile howsoever composed, and regarding the conductivity of electrolytes also we have a very thorough knowledge.

The researches in electrochemistry made during the last few years have led to a complete reversion of all previously-accepted notions as to the condition of substances in solution; for instance, in place of chlorid of sodium bound together by the strongest affinities, a solution of common salt is made out to contain free atoms of chlorin and sodium. What then are the facts forcing us to such an unheard-of opinion?

Imagine a dilute solution, for instance, of chlorid of sodium in much water. Such a solution, containing say one-half of 1 gram of common salt in one liter of water, is still a very good conductor. The conduction of electricity, however, takes place in this way: the ions (*i. e.*, the ingredients of the salt) carry it off; the sodium must needs transport the positive, the chlorin the negative electricity. For in electrolytes, according to Faraday's law, electricity moves only with the ions. Let us more fully dwell on this movement.

If we assume again the above-mentioned concentration, the solution contains to each atom of chlorid of sodium 1000 atoms of water. For equal distribution, therefore, we find in each line ten atoms of water alternating with two atoms of chlorid of sodium; consequently, if conduction is to take place, assuming even conduction to be a mutual exchange of ions, each atom of chlorid has to traverse five times the atomic distance before encountering an atom of chlorin with which to unite. Look at it from whatever side we please, we cannot help conceding the independent existence of atoms of sodium in the watery solution and this, at that, for a longer time than they exist in combination. More than that, however, is not claimed by the theory of dissociation either. Thus, by means of a series of different methods, which are a check one on the other, we are enabled at present to accurately determine the part played by an electrolyte divided into its ions.

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[*] Dr. William Ostwald occupies the chair of chemistry and electrochemistry at the University of Leipsic, Germany. By invitation of the German Institute of Electrical Engineers he read before that body at its second annual meeting (June 7–9, 1894) a paper on "The scientific electrochemistry of the day and its future technical application." The paper deals broadly with all the latest developments and is a perfect mine of new results and methods of research. Our attention was called to this glimpse into the twentieth century by Mr. Julius Meyer, a consulting engineer of New York, who has abstracted and translated for the Magazine that part which treats of the galvanic coal element.—THE EDITOR.

As a result we obtain a very simple rule for electric conductivity: in any electrolyte the conductivity is proportional to the quantity of ions contained in the unit of volume and, furthermore, proportional to two constants, which may be called the velocity of ionite migration. The velocity is a maximum for hydrogen. I shall not now enter any deeper into this matter, though it is not without interest; for of higher interest yet is the research for the electromotive forces, and this question has been solved by similar methods.

The basis of all discussion in this field of research is the osmotic pressure, and I shall explain first what this is. Five or ten years hence this would hardly be necessary, for then every person of scientific attainments will be as conversant with it as with gas-pressure. It is well known what happens when we superimpose pure water on a concentrated solution of any substance: the dissolved substance moves into the water. This movement or diffusion continues until everything is equally distributed. The cause which produces this movement and which is in the nature of a pressure is just what we call osmotic pressure. If one wants to convince one's self that one is dealing with a real pressure it is necessary but to prevent the movement of the dissolved substance. We should need to this end a partition impervious to the dissolved substance but not to the dissolving medium,—*i. e.*, water. It is not an easy task to produce such partitions, but in some cases it has been successfully done, and especially Professor Pfeffer has demonstrated by what means it can be accomplished. Employ such a partition and we will find the resulting pressures astonishingly high. A solution of salts such as the water of the ocean contains would exert a pressure of twenty atomospheres. Whence the pressure comes we need not discuss now; suffice it to say the pressure exists and is a property of all dissolved substances.

Any solid brought into contact with a fluid in which it can dissolve is capable, of course, of producing such a pressure. It is only necessary to envelop it in the above-described manner and, if we make the semi-pervious envelop so strong that the pressure cannot burst it, a maximum value of the pressure will finally be reached, depending on the solubility of the solid, and which can not be exceeded. This pressure is quite analogous to steam-pressure, and just as we utilize the latter in engines we can conceive of machines being operated by osmotic pressure. Well, a galvanic element is such an osmotic machine and it will now be perceived why I have gone to all this length to explain it.

In order to fully understand, however, we shall still have to investigate the process of the dissolution of metals in galvanic elements. Zinc dissolves into sulphate of zine. In the sense of the above-discussed conception the process involves the formation of electrically-charged zinc-ions from the unelectric metal. Simultaneously, however, if we base our contemplations on the Daniell cell, just as many copper ions enter into the unelectric condition,—*i. e.*, become ordinary metal. Positive electricity must, therefore, constantly be bound on the zinc electrode and the same amount be discharged on the copper electrode if the process is to take place at all; consequently, if we connect the two metals conductively an electrical process will occur simultaneously with the chemical process and neither of them can take place without the other one.

The reader is now conversant with the analogy between the pressure and the electromotive force. Precisely as we might operate a mechanical engine by means of two fluids of different steam-pressure, just so we may operate an electrical machine by means of two sources of different electrical pressure or potential. The zinc and copper of the Daniell cell are two such sources of current of different potential and the difference of their electrical pressure is based on the difference of osmotic pressure with which the zinc ions and copper ions are respectively endowed. The stronger the working pressure of the zinc and the weaker the reacting pressure of the copper, to be overcome, the more favorable the element,—*i. e.*, the higher is its electromotive force.

The pressure with which a metal tends to go into solution,—or its "dissolve-pressure," as we shall call it after this,—has a certain fixed value for every metal, and it might appear as though the two metals only and nothing else had to be considered in constructing galvanic elements. This, however, is not the case, and the impression is created simply because into this question enters another factor which has not yet been mentioned.

When the electrode of zinc is in contact with the liquid the effective dissolve-pressure clearly not only depends on the zinc, but there are zinc-ions in the solution which exert a reaction and can become effective only in the proportion of the excess of the first pressure over the latter. The electromotive force of the zinc, therefore, is the greater the smaller the reaction of the zinc-ions,—*i. e.*, the smaller the concentration in regard to zinc. It is well known, in fact, that the electromotive force of the Daniell cell is greater with sulphuric acid than with sulphurate of zinc.

The conditions are the reverse for copper; here it is advantageous to have the concentration of ions as great as possible, for a great pressure on this side assists the separating of copper.

These simple reflections constitute in the main the theory of the galvanic element. Originated by Professor Nernst, this theory differs from former so-called theories in that it does not approximately demonstrate prevailing conditions, but, comparable to Newton's law of gravitation, furnishes a quantitative theory controllable down to the most insignificant details. For this theory results in quite definite conclusions for definite premises and cases which at present can not yet be fully calculated are in that condition, not by defects of the theory but simply because the integration of the differential equations, which are known, has as yet been prevented by mathematical difficulties. Otherwise only the determination of the ruling constants is still lacking; quite a number are known even now, but of course some hard work has still to be done in this direction. Thus theory furnishes the means of finding the most suitable combination of substances for galvanic elements.

But there are problems of greater importance for electrochemistry to solve. We all know the defectiveness of our most common source of energy, the steam-engine. Under the most favorable conditions we realize of the energy stored in the coal but 10 per cent. in mechanical work. And we also know that the heat cannot be entirely transformed into mechanical energy, but we can calculate the fraction which is obtainable from a given quantity of heat of a certain stated temperature when we allow it to fall to another also stated temperature—and here again we find the utilized energy to be but one-seventh of the amount that might be transformed. This poor result is not chargeable to the steam-engine as a technical apparatus; the cause is found in the utilization of only the smallest part of the high temperature of the combustible, which at a low estimate is 1000 degrees, viz., that part between the temperature of the boiler and the temperature of the condenser. All that enormous difference of temperature between the combustion-chamber and the boiler is a total loss. There is only one way of improving thermodynamic engines: higher initial temperatures. How to accomplish that is for the technologist to find out.

But thermodynamic engines are not the only ones in existence and temperatures of 1000°, which it is certainly no small matter to handle technically, are not unavoidable. The maximum of energy that can be obtained by any one change of energy is theoretically independent of the process by which the change is effected. Therefore, if we could transform into mechanical energy the chemical energy of the combustible without resorting to heat, we should not be tied then to the uncomfortably high temperatures and might gain the entire amount without those discomforts.

The path on which this greatest of all technical problems—the production of cheap energy—can be approached; that path must be discovered by the electrochemist. If we produce a galvanic element which furnishes electrical energy from coal and the oxygen of the air and furnishes it in amounts somewhat in proportion to the theoretical values, then we shall face a technical revolution in comparison with which the one following the invention of the steam-engine will be dwarfed into insignificance. Think of the incomparably simple and elastic distribution of electric energy and imagine the change in the appearance of our industrial centers! No smoke, no soot, no boilers, no steam-engines, nay, even no fire, for fire will be needed only in the few processes which cannot be accomplished by electricity, and of those there will be fewer every day.

How the galvanic element in question will be constructed, of course, cannot even be surmised at present. Let me point out, however, an essential feature which is almost invariably misunderstood. The energy of the galvanic element originates in the chemical energy; that is indubitable. But not all chemical energy is changed into electrical energy. What then are the conditions for which the transformation is as complete as possible? Only the indirect chemical processes are electrically utilized!

Suppose we should take two vessels containing each a solution of potassium sulphate and connected by a filled siphon. We put a rod of zinc into the one and a rod of platinum into the other vessel. If we connect the two metals over a galvanometer a current of but very short duration occurs and the needle of the galvanometer comes directly to rest again. We know this to be the consequence of the polarization and also know that a continuous current may be obtained by the employment of an acid in place of the neutral fluid. Suppose we employ sulphuric acid. Into which of the two vessels would you want me to pour it to produce a current? Whosoever had this question put to him unhesitatingly answered: to the zinc of course, for the zinc must dissolve! But, my asking the question may convey the hint that the matter is different. We pour the acid to the zinc—no action! We pour it to the platinum, and we perceive the needle fly to the stop.

We arrive thus at the seemingly absurd result that the acid must be poured into the vessel not containing the substance on which it is to act. That applies quite universally. Some years ago I published a long series of experiments which proved the validity of this principle for entirely different reactions. And that is by no means an unforeseen or unexplainable fact, but the experiments were made because I had to expect the demonstrated phenomena from the theory which at that time was only just shaping, although at first blush they appeared scarcely plausible.

But if we bestow some more thought upon the nature of these processes we soon perceive that they could not possibly take a different course. If the zinc is to dissolve it must form ions and to that end take up a certain quantity of positive electricity. To make this possible an even quantity of positive electricity must leave the solution, so that an equivalent quantity of hydrogen relinquishes its ionite existence and is transformed into common hydrogen. The discharge by the fluid of positive electricity can not take place at the spot where zinc dissolves, for there the electricity is moving in the opposite direction. There is therefore no alternative but for hydrogen to escape at the cathode conform to the actual occurrence.

The explanation plainly shows the futility of the procedure of the late Joblochkoff when, some years ago, he tried to produce electrical energy from coal direct. He put the coal into melting niter from which to obtain oxygen and the resulting violent combustion actually generated current, but so weak a one that it could not be utilized. Now we clearly perceive the reason of his failure : the niter does not belong with the oxidable electrode, but with one not attacked by oxygen. Surely in the Bunsen element we do not pour the nitric acid on the oxidable material, zinc, but on the coal, which under these conditions is not oxidable.

Therefore our future coal element will have the oxidizing medium on the side not containing the coal to be burned, and that medium must either be the oxygen of the air itself or some other oxidizing substance produceable in quantities from the same. In its chemical process such an element would be like an ordinary stove. Coal is shoveled in at one side and oxygen admitted from the other ; carbonic acid escapes as product of the reciprocal action. A suitable electrolyte has still to be added to bring about the electrical process. The electrolyte only acts as an interposed substance and will not be consumed.

This is not the place to detail the technical features which might lead up to the desired result ; it will be some time hence before we shall be able to seriously cope with this problem. But I will say this much: we are not chasing rainbows, but we are dealing with a case the success of which is as much within our horizon as that of any other mechanical problem. It is left to technology to find the cheapest and best form for its practical application.

The work of science in a case like this is positive as well as negative; it shows what can be accomplished, or it may say: "this can surely not be done." The work of the inventor, however, is not superseded thereby. Science answers only yes or no, when interrogated, and in many cases it has no answer at all. The inventor has the difficult task of shaping the problem and advancing it to the point where the question may be put to science—and when it is put, how many times is science forced to confess: That has not yet occurred to me!

ELECTRIC WELDING AND METAL-WORKING.

By Hermann Lemp.

SO many able papers have been published on the subject of electric welding and electric metal-working that there would seem to be nothing more to say on the subject, in a general way; but so far as individual appliances and experience are concerned, much more may be said.

Before entering upon the study of the art of electric welding and metal-working as originated by Professor Elihu Thomson, I will endeavor to review all known attempts and processes of electrically heating metals, and shall consider myself justified in devoting to the Thomson process the principal part of this paper.

With the commercial introduction of the arc-light (in 1881) one of the first characteristics of the arc noticed was its great localized heat; it was, indeed, this very heat that was necessary for volatilization of carbon. Metals heretofore known to be refractory to melting processes, such as platinum and the like, would be melted down with ease whenever introduced into the path of the arc.

Werner Siemens, then the pioneer in electric-lighting in Europe, constructed the well-known electric furnace for the melting down of ores or metals requiring the very highest temperatures. It consisted of a conducting crucible of graphite which was made one of the poles of a powerful continuous-current dynamo, while the other terminal was connected to a piece of circular carbon, held centrally with respect to the crucible. The two poles were first made to touch, and then an arc was drawn by withdrawing the central carbon. Any ore or metal thrown into the crucible would be under the direct influence of the arc, and be melted with ease. The crucible generally formed the positive pole. This process, free to every one, is quite practical for laboratory work, especially for experimental alloying of metals. The necessary apparatus is simple, and current can be used from any ordinary incandescent-lighting dynamo of the continuous-current type. It may be noted that in this process one electrode may be partly the crucible and partly its fused contents.

The next application we find was made by De Meritens, a Frenchman, who substituted for the crucible the metal object itself; from this an arc was drawn similarly to that in the Siemens furnace. This process, now generally known as the arc process, was further elaborated by a Russian named Bernardos, who not only carried out experiments on a large scale, but through his English sponsors, the well-known firm of Lloyd & Lloyd, obtained commercial results in two specific lines.

The first of these, the filling of blow-holes in castings, has saved many a costly product which would otherwise be condemned to the scrap-heap. The only precaution to be exercised is to previously heat the casting to be treated to a dull red heat, by an ordinary furnace burning either coke or oil, and then to apply the arc, making the casting the positive pole. If the casting is not heated as described, the filling made by the arc will, in shrinking, break away from the matrix, or will crack.

The second application is to the longitudinal welding or soldering of plates that have already been riveted. Where the metal to be heated is thin, the heat of the arc alone is sufficient without additional means. It is impracticable, however, when the material to be worked is massive and likely to rapidly conduct the heat away from the surface under treatment. Complicated pipe-flanges, Westinghouse air-receivers, etc., have been welded by this process. The electric arc so applied appears to act as an economical and intense blow-pipe. The necessary apparatus is a continuous-current generator of not less than 110 volts (preferably 150), an adjustable resistance in series to modify the strength of the current for various work; a carbon-holder with a shield to protect the operator from the radiant heat of the arc, and a shield for his eyes, consisting of a number of superposed colored glasses. The current employed varies, according to the size of work, from 10 to 350 amperes. No flux is required. This process is, however, limited to but few applications, and, while handy for specialties or repair work, is limited to surface work. It also can be used for chilling the surfaces of soft castings, as, for instance, knife-edges for scales, etc.

In the above methods, the piece to be worked upon forms, either in part or in whole, one of the electrodes from which the arc is drawn.

Another electric-heating process, utilizing the arc and more closely resembling the action of a blow-pipe, is that devised by Werderman, and the apparatus for carrying it out is known as the Werderman electric blow-pipe. In this apparatus, a small permanent steel magnet, or electromagnet in series with the arc proper, exerts a repelling effect upon the arc, which, like the flame of a blow-pipe, may then be directed against an object to be soldered or otherwise treated while hot. This blowing effect on the arc is produced by the effect of two currents trying to produce magnetism in opposite directions. The arc flame, which is a flexible conductor, tries to set itself in harmony with the magnetic field of the electromagnet.

This process has not found any practical application to speak of, but may, undoubtedly, be of value in specific cases,—for instance, where the oxyhydrogen flame is now used as a source of heat. The cost of the latter, however, is far beyond the running expenses of an arc-light. A somewhat similar effect can be obtained by using an air-blast in the place of the magnet, or the arc may be formed in an inclined position, so that a natural draft carries the flame upward against the object to be heated. Copper wires may be brazed in this manner.

Another application of the arc—one which has not been ascribed particularly to any one person, but has been practised by many—consists in approaching two wires forming the two poles of say a 50-volt circuit, then separating them so as to cause an arc to bridge the gap, in which position they are held awhile until both terminals are at a white heat or melted, and then they are quickly pushed together, after which all heat disappears. The positive pole, as usual, is the hottest, and a large ball forms on the same into which the negative terminal is pushed. The writer used this process many years ago for joining platinum wires to copper wires used in the manufacture of series incandescent lamps, and also, together with Mr. Merle J. Wightman, made use of this principle as a safety device in incandescent lamps running in series with arc-lamps. This process works fairly well for such purposes as these, where electric conduction is required, while mechanical strength is of slight consequence.

Still another process, which has been brought to notice of late in Belgium, has caused a good deal of surprise to the ordinary observer on account of its apparent inconsistency with established experience. It was originated in Belgium, and consists in passing a continuous current through a receptacle filled with a moderately conducting fluid, such as acidulated water, carbonate of potash solution, or the like, contained in a metallic receptacle or a nonconducting vessel lined with lead plates. When an iron bar connected to the positive pole (the vessel being made negative) is plunged into the liquid, an arc is formed around the submerged portion which will bring it to a white heat in a short time. The piece can then be removed and hammered on an anvil, or welded by the ordinary blacksmith's method to another bar similarly heated.

The heated metal seems to be clean and free from dirt and oxid, due doubtless to the protecting film of hydrogen which forms on its surface. The temperature, however, is not easily controllable, and the utility of the process is confined to easily weldable iron, or low grade steel, and to pieces of very simple form. High-carbon steel will be burned. Furthermore, pieces to be welded together cannot be held together while being heated, but must receive heat as in a blacksmith's forge previous to working. A similar result may be obtained by using, in place of the conducting liquid, a receptacle filled with loose charcoal, graphite, metal oxids in powder, or even melted metal.

The processes just described are chiefly of recent date. Joule, as early as 1856, buried a bundle of iron wires in charcoal, through which an electric current was made to pass. The charcoal thus heated, in its turn heated the iron, which at places was found to stick together. The nearest approach to a practical application of this process is the heating of wires by pulling them through a carbon tube which is kept hot by an electric current. Such a machine was described by Siemens in London, and has also been experimented with by the writer for continuously heating nail-rods.

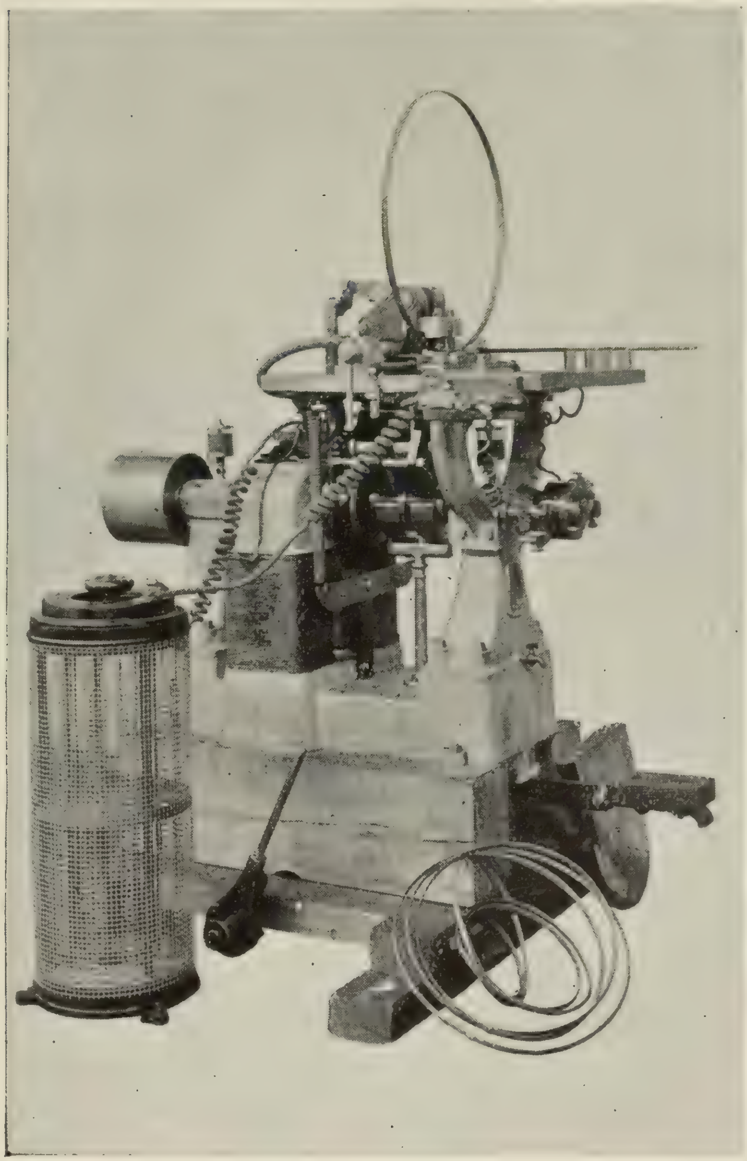

FIG. I—DIRECT-WELDING APPARATUS.

It will be perceived that, in all the processes described, the object has been to create artificially a high resistance at one point in an electric circuit, and, by employing an electric current of sufficient electromotive force, to overcome this resistance, and in so doing heat the

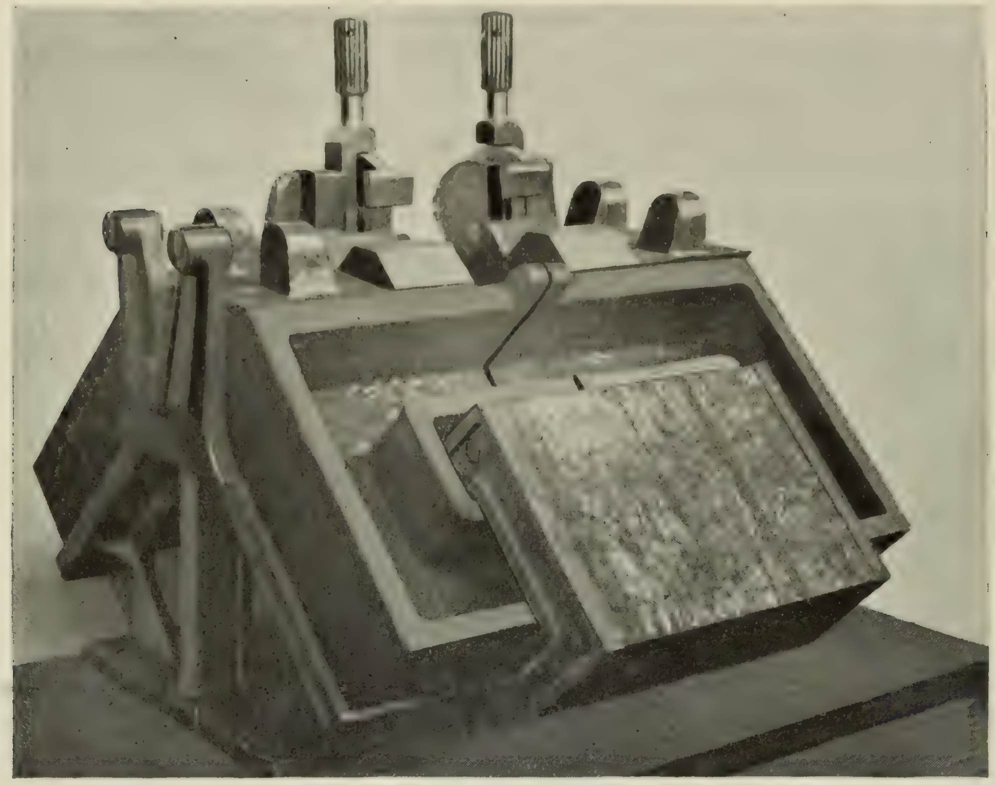

FIG. 2—COMMON FORM OF TRANSFORMER.

point of highest resistance. The difference in resistance between the metal to be treated and the medium through which the current passes has, however, always been so great that the heat has been too much localized, creating only surface heating, which permits the metal to chill at once upon stopping the flow of current. The temperature at the surface is, furthermore, too high and liable to cause blisters.

Professor Elihu Thomson early saw the limitations of the processes mentioned above, and, years ahead of the practical advent of his now well-known process, had its elements clearly in his mind. This process differs radically from all the others in *forcing through the metal to be heated electrically such volumes of current that its own resistance is sufficient to bring every molecule of the section traversed by the current to the desired temperatnre.*

In the processes and experiments heretofore described, the heat was not generated in the metal or the joint itself, but always either in the surrounding envelop and communicated to it through conduction, or in the contact between the metal and another high resisting medium. In the Thomson process, for the first time, the heat is generated in the metal itself at the joint, and not communicated to it. We will see the importance of this by comparing it with the ordinary forge heating. In this a bar of iron is inserted in a fire, or put in contact with live coal. The heat communicates itself to the iron by conduction and radiation, and, in proportion to the increase of temperature in the iron, increases its resistance to the further reception of heat from the source. In other words, in heating any object by communicating heat to it from outside a condition is soon reached, after which either more energy or time will be required to further increase the temperature. Now, let us heat the same bar of iron by an electric current; we find that the hotter the iron becomes, the more easily its temperature is further increased. In the former case of heating from the outside, the surface to which the heat is applied is the hottest, and the core or interior where the heat is wanted is the least hot. In the electric process, it is the *core* which is best protected from radiation and which will become heated first. There is, however, another difference more important from the standpoint of economies.

By the forge-fire method, only part of the heat generated is communicated to the metal. In the electric method, heat is generated in the metal itself, and all the energy forced through the metal is usefully applied.

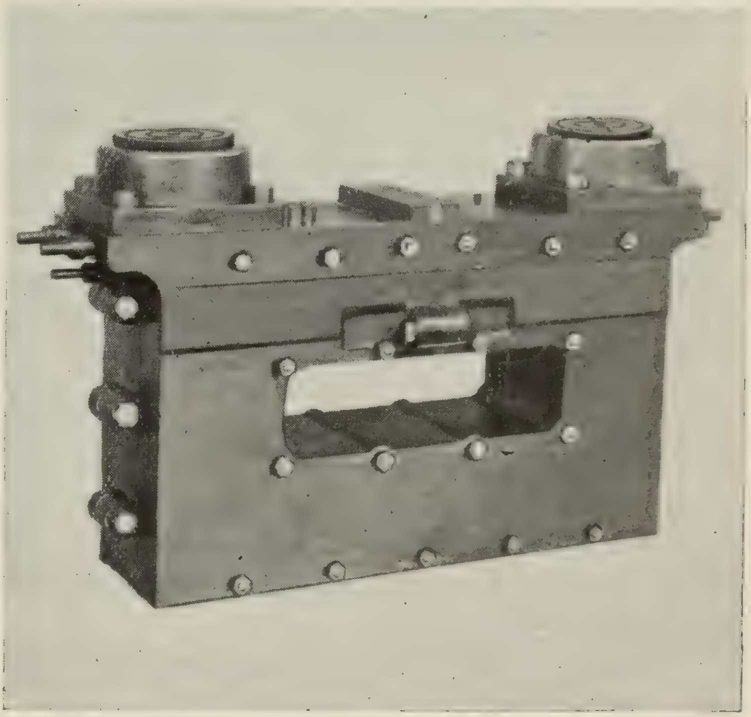

FIG. 3—TRANSFORMER FOR LARGE APPARATUS.

What I wish to show is that in the electric method of heating we can increase the *rate* of heating, or, in other words, shorten the time necessary to heat a piece of metal without sacrificing uniformity, by simply increasing the electrical energy expended in the circuit; while to increase the rate of heating in a fire, we are obliged to sacrifice uniformity, and increase the waste proportionately or more than that. By this electric process, therefore, (1) we utilize, practically, all the energy; (2) we can increase and

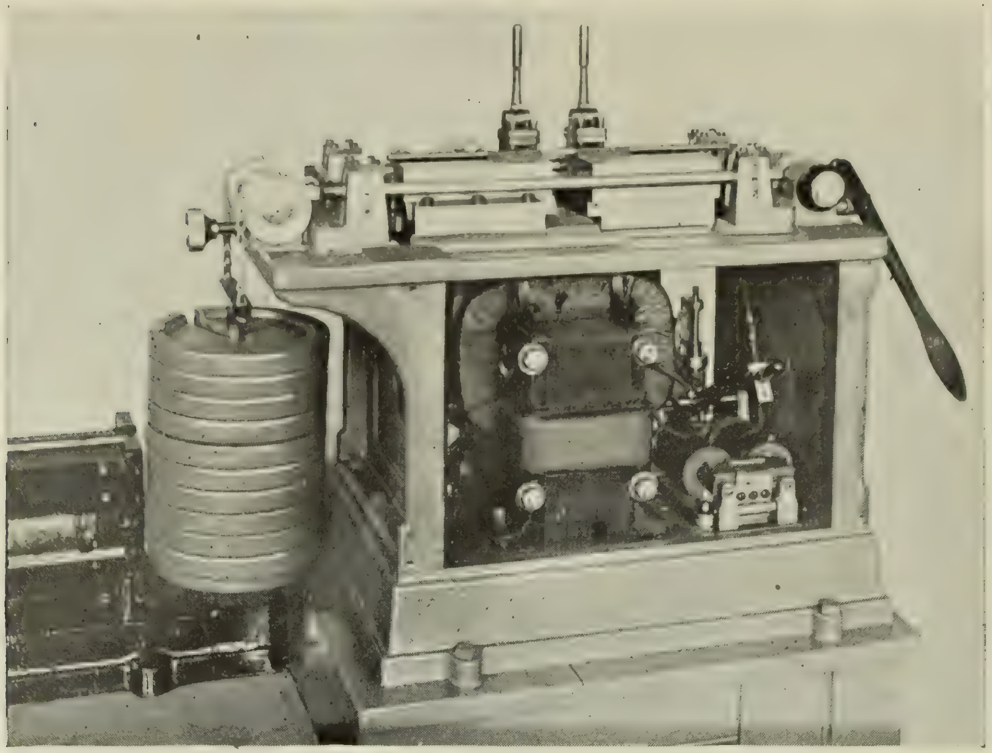

FIG. 4—AUTOMATIC WELDING-MACHINE.

decrease the rate of heating at will ; and (3) we can stop all further loss of heat by the simple removal of the metal pieces (the sources of heat) from the circuit, or by switching off the current.

Thomson's welding process consists in passing an electric current of great volume, by means of two clamps of good conducting metal (generally copper), through two pieces firmly abutted against each other between the clamps, which, when heated by the current, are forced together by mechanical pressure. The metal between the clamps alone possesses the requisites for the conversion of electrical energy into heat. The only loss of energy to be counted on will be that caused by conduction of heat to the clamps of the apparatus, by radiation, and the resistance loss in the electric generator and welding machine. By increasing the speed of operation the first two items, which are alone of importance will be reduced.

The apparatus generally used to carry out the Thomson process is—

1. A generator of alternating currents.

2. A welding transformer provided with clamps and mechanical appliances to work the heated metal.

3. Electrical regulating apparatus to control the flow of current.

The generator is best when of a low periodicity. For the past five years fifty cycles per second have been used, and even lower ; twenty to

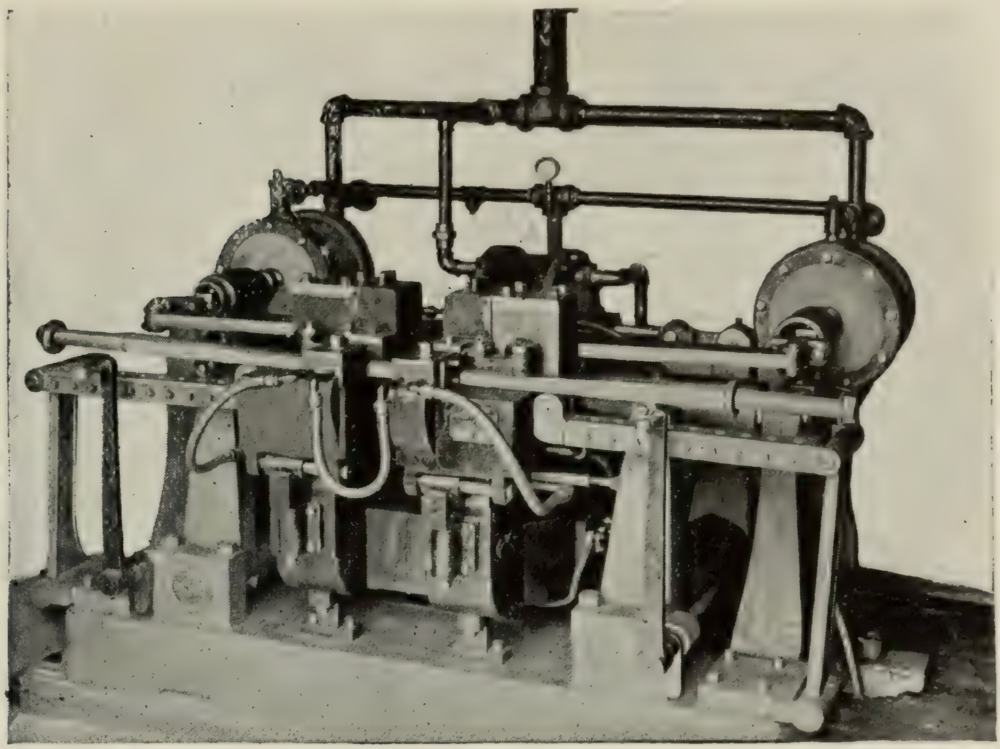

FIG. 5—APPARATUS FOR WELDING CARRIAGE-AXLES.

thirty could be used to advantage on large work, owing to the great self-induction which the work proper creates. When one considers the immense volumes of currents required for welding copper, approximating 60,000 amperes per square inch of metal, he can imagine the density of the alternating field surrounding the conductor. Other things equal, the self-induction will be proportional to the periodicity, and so will be the corresponding increase of current above what would be needed to convey the necessary energy to the metal, if there were no self-induction. The generators are not different from those found in electric-lighting, except in voltage and periodicity. They can be used for lighting if required.

In some apparatus, known as direct-welders and used only for small work, the alternating currents for welding are generated in the dynamo and carried to the clamps directly, without transformation, and the clamps and mechanical pressure devices are all incorporated in the dynamo. [See Figure 1.] The transformer, however, is usually employed in practical work. Through its agency small currents set in motion by high electromotive forces can be converted into currents of great volume with small electromotive forces, just as light belts running at high speed are made to transmit, by means of proper pulleys, the same mechanical energy as slow-running, heavy belts. The product of the feet per second and pull in pounds exerted by the belt measures

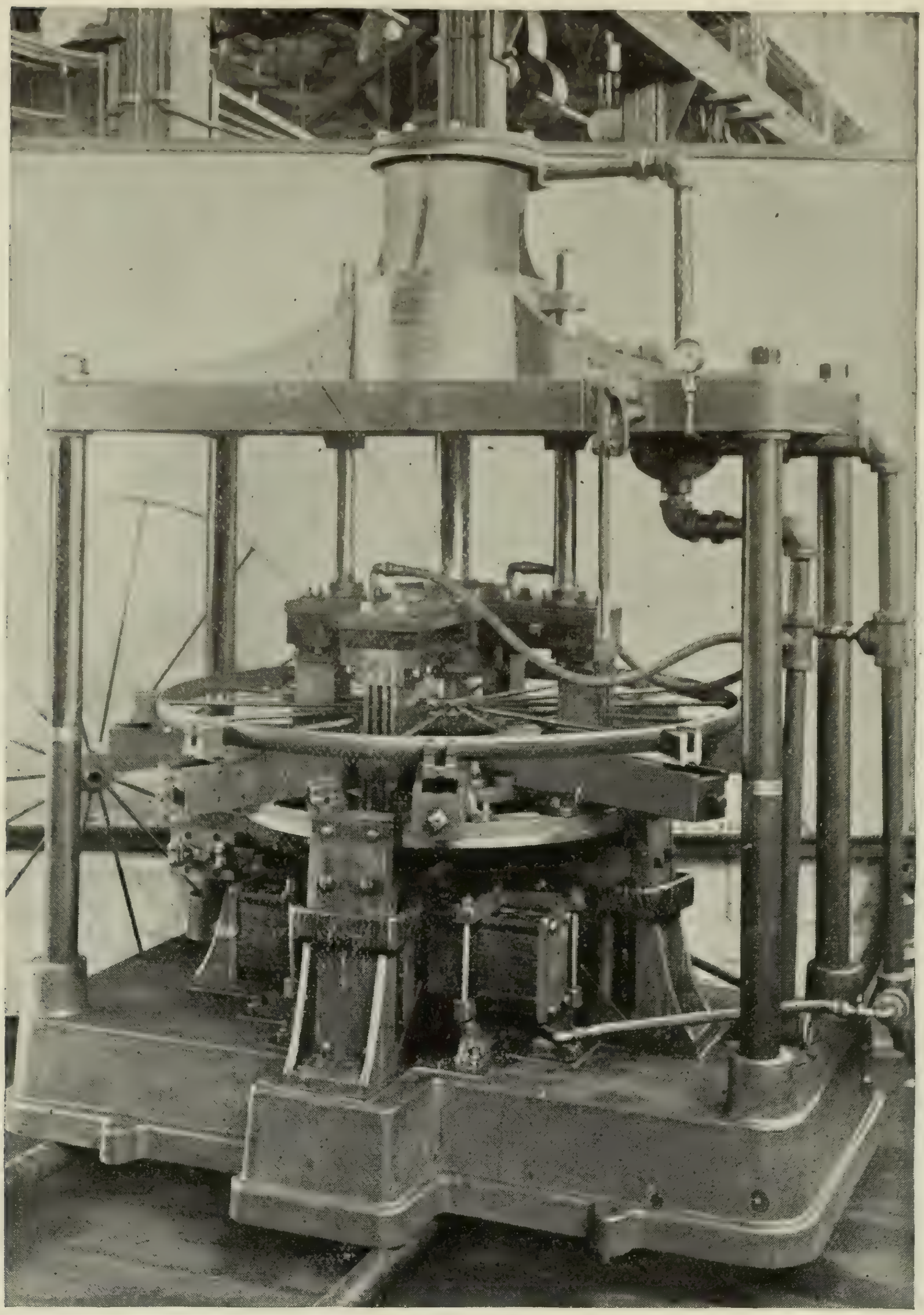

FIG. 6—MACHINE FOR WELDING WHEEL-SPOKES TO HUB.

the energy conveyed. So, roughly, the product of the length of wire and density of current flowing through it may measure electric energy. A belt transmission and electric transmission are analogous, and the latter is explained by the former. The electric transformer is just as simple an apparatus as any set of pulleys,—in fact more so, on account of the fact that none of its parts are revolving. Friction in a belt transmission is equivalent to resistance in the magnetic and electric circuits.

Slippage is equivalent to what is known as magnetic leakage. An electric transformer in which the two windings are not closely related to each other, which allows a leakage of magnetic lines to take place between them, is comparable to a friction-pulley power-transmission. If the load to be transmitted exceeds the friction, a slip will occur. A properly-constructed transformer is like a positive coupling. It will transmit all the energy put upon it, or break down itself, or cause the generator to break down. This property is obtained by having the secondary conductor of a transformer completely surround the primary.

Figure 2 shows the most common form of transformer. It is a copper casting with either one or two grooves cut at one side ready to receive the primary winding, and its two terminals or poles respectively connected to the pieces to be welded by means of sliding-contact surfaces. These forms are generally used in connection with a horizontal table for supporting the work.

For large apparatus, especially when the transformer itself is to be moved bodily to and from the work, the shape in Figure 3 is used. For this construction, the secondary is composed of two halves, which are bolted together with these grooved surfaces meeting. In the hollow rectangular frame thus formed, the primary coil lies both mechanically and electrically protected by the secondary. It is often customary to fill the intervening spaces with oil, which completes the insulating

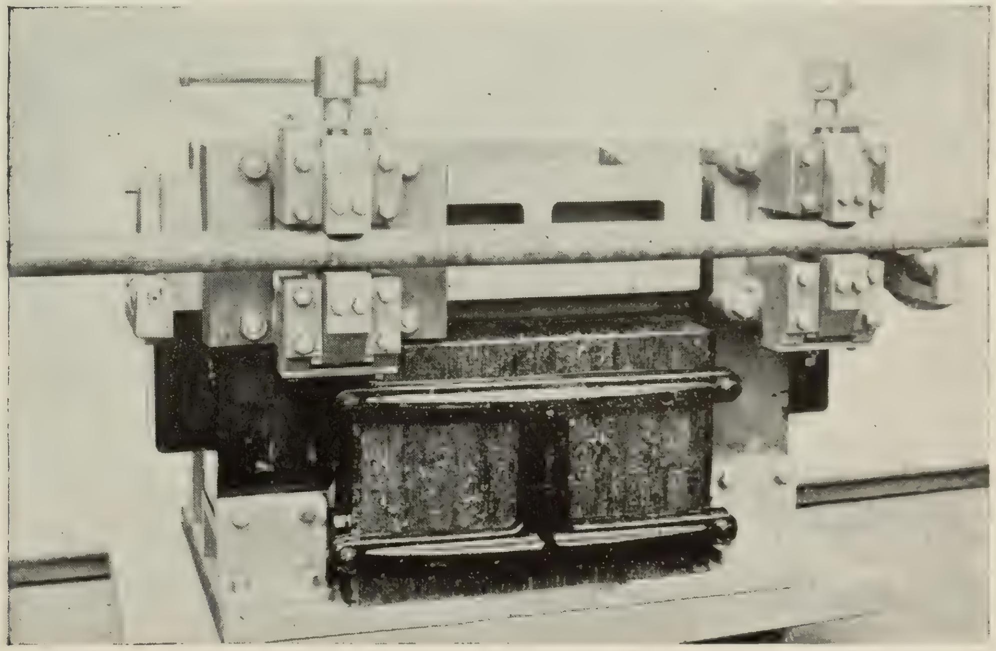

FIG. 7—TRANSFORMER FOR HEATING PIPE FOR BENDING.

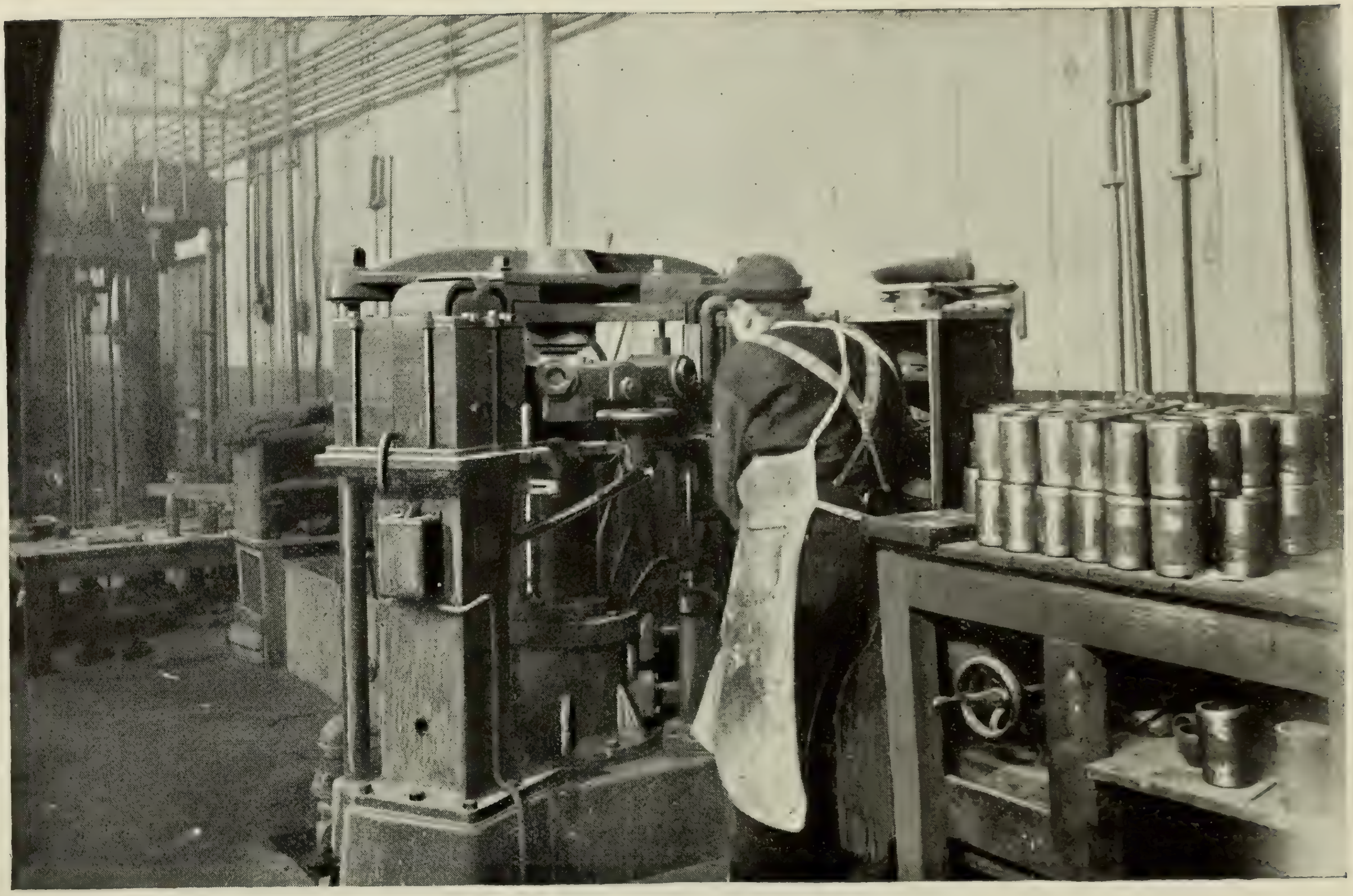

FIG. 8—APPARATUS FOR WELDING SHRAPNEL SHELLS.

properties, and permits a free communication of any heat generated in the primary to the outer walls of the secondary, from which it will be dissipated. These transformers have practically no leakage between primary and secondary. The only limiting item to transmission of energy through them is the ohmic resistance of the two windings.

The electric current is generally regulated by means of a reactive evil in series with the primary of welders or by rheostat in the field circuit of generator.

ENERGY ABSORBED IN ELECTRIC WELDING.—PROF. THOMSON'S PROCESS.

IRON AND STEEL.					BRASS.					COPPER.				
Area in □″	Watts in Primy. of Welders.	Time in″.	H. P. applied to Dynamos.	Foot lbs. unit 1000.	Area in □″	Watts in Primy. of Welders.	Time in″.	H. P. applied to Dynamos.	Foot lbs. unit 1000.	Area in □″	Watts in Primy. of Welders.	Time in″.	H. P. applied to Dynamos.	Foot lbs. unit 1000.
0.5	8550	33	14.4	260	.25	7500	17	12.6	117	.125	6000	8	10.	44
1.	16700	45	28.0	692	.5	13500	22	22.6	281	.25	14000	11	23.4	142
1.5	23500	55	39.4	1191	.75	19000	29	31.8	508	.375	19000	13	31.8	227
2.	29000	65	48.6	1738	1.	25000	33	42.0	760	.5	25000	16	42.	369
2.5	34000	70	57.0	2194	1.25	31000	38	52.0	1087	.625	31000	18	51.9	513
3.	39000	78	65.4	2804	1.5	36000	42	60.3	1390	.75	36500	21	61.2	706
3.5	44000	85	73.7	3447	1.75	40000	45	67.0	1659	.875	43000	22	72.9	872
4.	50000	90	83.8	4148	2.	44000	48	73.7	1947	1.	49000	23	82.1	1039

The table on this page shows the energy taken for the three typical materials—iron, copper, and brass—of various sections. The greater the power, the shorter the time, and *vice versa*. Certain materials have to be heated very slowly to prevent over-heating Materials that are changed in nature at high temperature, and that are easily fusible, such as copper, brass, tool steel, etc., are best welded rapidly. There is no opportunity given in rapid welding for deterioration of the metal, and whatever metal has been hurt is pushed out from the joint under longitudinal pressure. This method of rapid welding has come into greater favor of late, and, inasmuch as an increased product is obtained by it, most users disregard the increased first cost of larger machinery on account of the benefit of increased production and uniformity. Under ordinary circumstances, we may say that 7 horse-power-minutes is a safe figure for bringing one cubic inch of metal to welding heat. This is practically the same for copper, brass, and iron, with the distinction, however, that for metals which conduct heat easily, a shorter time and correspondingly greater power must be used to prevent loss from both radiation and conduction. If the pieces to be welded are short and wide making the conduction by the clamps great, from 10 to 15 horse-power minutes per cubic inch are required.

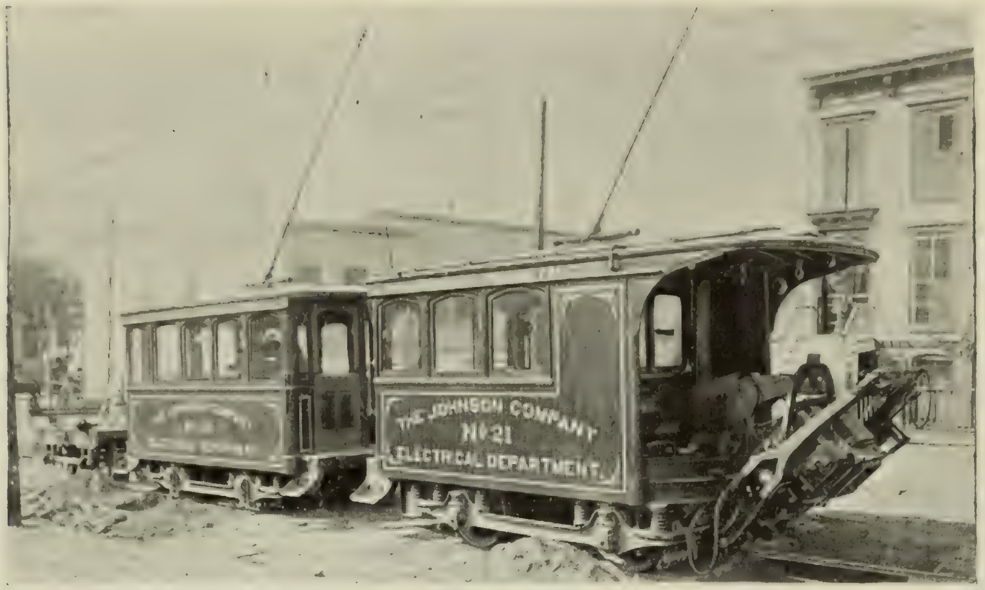

FIG. 9—JOHNSON ELECTRIC WELDING TRAIN.

In the table just referred to the stock to be welded is assumed to be held in the clamps with a distance between clamps of twice the diameter of round material for iron, three times for brass, and four times for copper. For heating iron or steel bars, as in upsetting or in ordinary forging operations, when of lengths not shorter than a foot, from 3 to 5 horse-power-minutes per cubic inch will be required to bring them to a bright red heat, and from 4 to 10 horse-power-minutes to bring them to a white heat, such as is used in blooms for rolling.

It is interesting to note that calorimetric methods have proved that, of all the electrical energy put into the metal to be heated, fully 75 per cent. is useful. The 25 per cent. missing is mostly lost by radiation and conduction, showing a high efficiency of the electric conversion into heat, and that the actual cost of fuel for welds in an open forge and by the electric process is about equal under continuous working conditions,* while, with discontinuous working, the electric method is far ahead in economy. This has been rather a surprise to many, the question of fuel expense having always been regarded as settled to be greater for the electric process.

The numerous experiments which have been made to store up the energy between welds by means of fly-wheels, storage-batteries, etc., the energy to be returned during welding, have been without practical results. The problem in most cases has been solved by the farsightedness of the American manufacturers in disregarding first cost, and installing apparatus large enough to have a surplus of energy. In every

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*See paper read by Sir Fred Bramwell, of E. I. M. E.

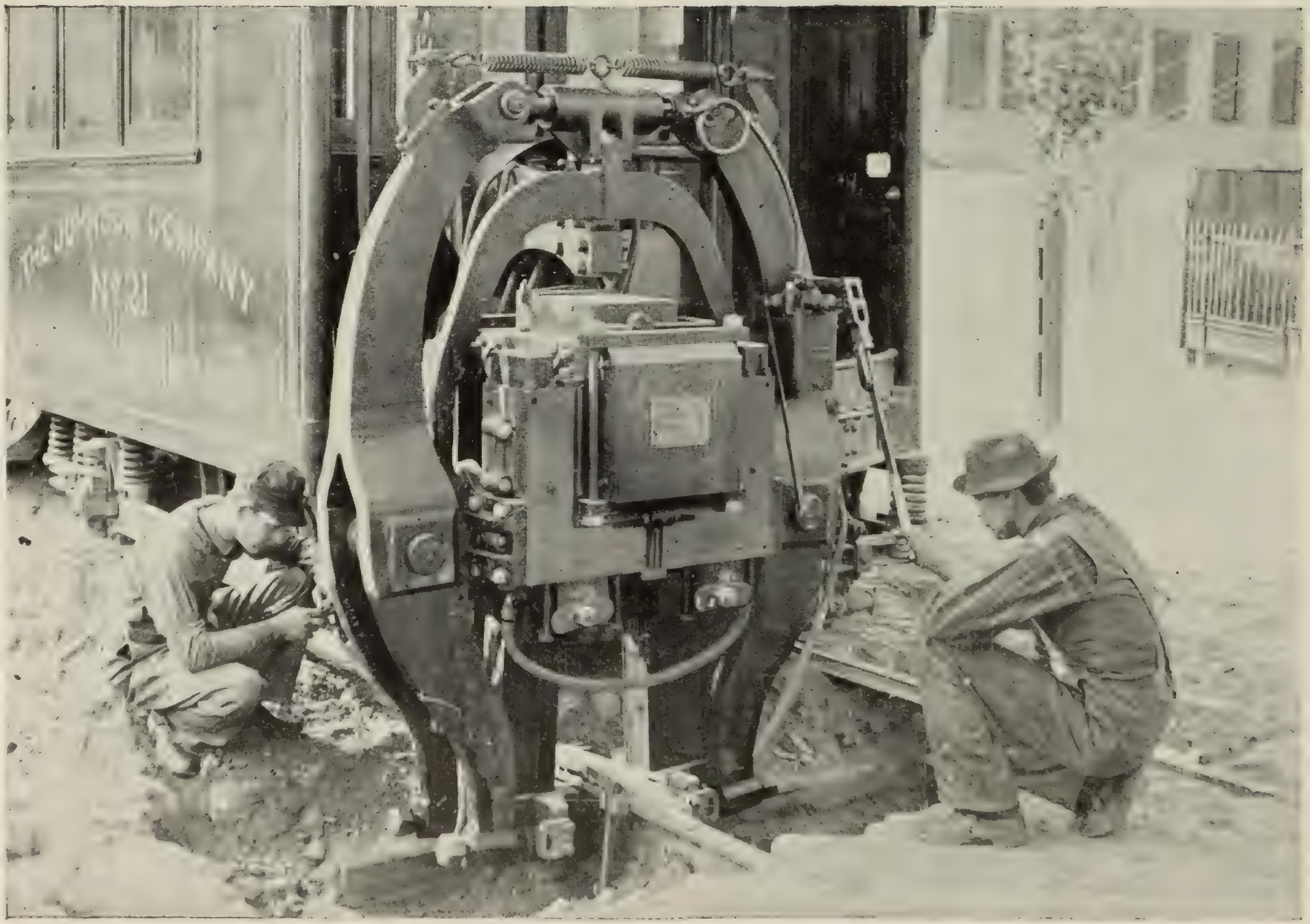


FIG. 10—WELDER OF THE THOMSON SYSTEM AT WORK ON THE NASSAU ELECTRIC RAILWAY, BROOKLYN.

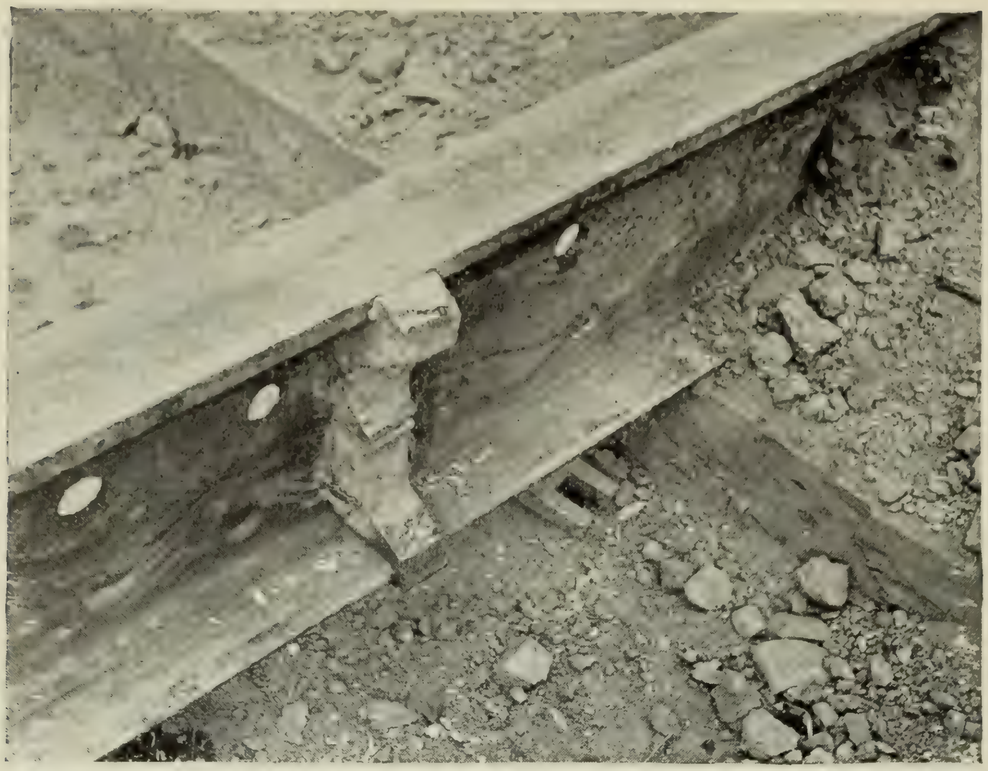


FIG. II—ELECTRICALLY-WELDED STEEL RAIL.

case this has proved to be the best, but with electric energy directly available from a central station, the manufacturer is able to dispense with the surplus energy, and throw this responsibility upon the central station. A large number of customers, operating from one source of power, will never draw this surplus at once, but the surpluses will overlap each other and out of individually irregular demands will result a fairly even average demand. The electrical energy necessary for welding, can, therefore, in many cases, be obtained directly when within the district of an alternating-current supply, by means of an ordinary transformer, or when within the district covered by the now commonly-employed power-stations, furnishing current of 500 volts, by means of a rotary transformer, more generally known as a motor-dynamo. By means of the latter machine, an amount up to 200 horse power is to-day successfully transmitted for welding street-car rails in the street.

The great advantage of such a device as the motor-dynamo consists in its flexibility and ease of manipulation, and its ability to transmit great overloads for short periods. A steam-engine overloaded stops ; an electric motor or transformer, properly constructed, will rise to the occasion, although, if too long continued, it will break down.

The practical applications of the Thomson process to various industries will now be described briefly. Wire-mills were early to recognize the advantages of the electric process for disposing of their shorts, incidental to the manufacture of wire, on one hand, and satisfying the demands of the trade for longer coils. Automatic machines are mostly used for this purpose ; that is, machines in which all conditions for good work are automatically maintained without requiring a special experience on the part of the operator. [See Figure 4.] Weights at the left determine end pressure, adjustable stops, the distance between clamps, and knurled screws at the left, the shutting off of the current by means of the magnet shown at the right. Nearly every wire-manufacturer of repute in the United States has either one or more of these machines. The firm of John A. Roebling's Son & Co., in Trenton, are making, on the average, 600 welds per day of ten hours, on telegraph wire. Most of the time is used in the handling of the heavy wire coils, as is seen by comparing the above output with the welding of brass wire loops and steel harness-rings done at the works of the Thomson Electric Welding Company, in Lynn, for outside customers, in which case the daily product of ten hours is 3000 and 1000 welds respectively. The increase in speed is simply due to quick handling of light objects as compared with heavy coils.

Mr. Roebling stated in 1892 that, of more than 1,000,000 welds made by his firm, not a single case of a bad weld had come to his knowledge. Carriage-builders are largely users of the the electric process. Tires, hub-bands, dasher-frames, carriage-steps, and axles are welded in large quantities. Figure 1 shows a direct welder on which baby-carriage tires are welded at the rate of 1500 to 2000 in ten hours.

The hand hydraulic pressure, as used on some of the large machines, may be replaced by a special pump and accumulator controlled by a valve. Such a machine is shown in Figure 5, which was designed to weld carriage-axles of all dimensions up to 2 inches round. Both the clamping of the stock and the end pressure are hydraulic, relieving the operator of nearly all manual work.

The manufacturers of metal wheels have also found it advisable to use the electric process. Figure 6 shows a machine designed to fasten the spokes of a metal wheel in the hub by welding two halves of a hub together, including the spokes between the welded surfaces, and of riveting the spokes in the tire by heating them electrically at their contact with each other.

The much-dreaded welding of high-carbon steel, in the experience of the ordinary blacksmith methods, has, in the Thomson process, been rendered comparatively easy. This has been fully demonstrated by the Standard Tool Company, of Cleveland, who are manufacturing reamers, twist-drills, taps, etc., in enormous quantities, the characteristics of which are that only the cutting part of the tool is composed of tool-steel, while the shank is of a good grade of machinery steel. Not only is there a saving in the manufacture, but also a better product is obtained ; the shank is tougher and less brittle.

Recognizing the utility of the electric process, not only for welding commercial pipe length into endless coils, but also applying the same process to locally heating sections of pipe for bending, a special company was organized, the Electric Pipe Bending Company, for making continuous coils of every description.

In making continuous circular pipe the welder is mounted on a railway truck, and, while the pipe heated in a coke-stove between welder and coiling apparatus is gradually wound up in the latter, a new piece of pipe is welded to the traveling end.

Figure 7 shows an electric transformer for heating twenty-five inches of 2-inch pipe for bending. The average daily product with one set of apparatus (one welder and one heater) is 5000 feet of 1-inch pipe, 3500 feet of 2-inch pipe bent, 3500 feet of 1-inch pipe, 2000 feet of 2-inch pipe welded and bent.

An industry owing its existence entirely to the electric-welding process is the manufacture of high-grade projectiles, carried out by the American Projectile Company. By combining the welding process with forging and hydraulic pressing, a projectile can be produced which, in price, is nearly equal to the old and unreliable cast-iron shell, and which, in quality, far surpasses the latter. Official tests have proved the shells inferior to none, while in the method of manufacture there are possibilities to still further increase their efficiency without increasing the cost. The principle involved is, briefly, to unite two forgings, representing respectively the base and point of shell, by electric welding. The point can be made of very high carbon steel, while the body and base may be ordinary machinery steel. Figure 8 shows the apparatus on which shrapnel shells are being welded.

An example of what a progressive mind will accomplish is given by the Johnson Company of Johnstown, Pa., who, under the able leadership of Mr. A. J. Moxham, have applied the electric-welding process in a manner that has almost startled its own projectors. I am not able to produce any photograph of the ponderous welding-machinery used in this work but will only give a few figures to show the magnitude of their undertaking. There are, approximately, ten welders in use, of an aggregate of 1200 horse-power. From 12 to 16 square inches are currently welded. A single weld of 48 square inches even has been produced. The product is railway-switches, crossings, frogs, chairs, special rails, splice-bars, etc. All track constructions heretofore bolted are being replaced by welded-together rolled structures, thus furnishing an excellent wearing material, proof against being thrown out of shape by loosening of bolts or rivets. The latest application—one which has caused no end of discussion, and which is past the experimental stage—is the welding of rail sections into one continuous track for electric street-car service. Mr. Moxham has demonstrated that a continuous rail can be made, buried in the ground, and made to withstand the variations of temperature that are met with in this climate. At present he is carrying out the commercial laying of tracks electrically welded on the spot with apparatus furnished by the Thomson Electric Welding Company. Since this plant may be regarded as, in one sense, typical of the utilization of electric energy furnished from a central point to metal-working at any point within its distributing district, it may be well to briefly describe the apparatus.

Figure 9 shows the welding-train, composed of a dynamo-car, in which a continuous current of 500 volts and approximately 275 amperes is transformed into alternating currents of 300 average electromotive force and 650 amperes, which currents, after passing through an adjustable reactive coil, enter the primary of the welding transformer, suspended from a boom in the welding-car. The motor-dynamo is of peculiar construction, having only one winding. It is a regular continuous-current motor with commutator having (in a two-pole motor) two of its commutator segments 180 inches apart, connected with two collector-rings. It is virtually a revolving commutator, alternately connecting the two poles of the welder primary with the trolley and ground circuits in opposite directions. The efficiency of such a motor-dynamo is very high, (about 92 per cent.), and about 30 per cent. more energy can be transformed by its use, as compared with the mechanical energy that can be delivered by the pulley on armature shaft when used as a plain motor. This is because twice in each revolution there is a direct connection between welder and line, without using the armature windings.

The welder shown separately on Figure 10 has two transformers with oil insulation and can be operated with immunity from electric shocks in pouring rain. A hydraulic jack, operated by a hand-pump shown at the right, furnishes the necessary pressure. The cars are equipped with electric motors for hoisting and swinging welders, pumping water for water circulation in jaws, grinding the surface of the rail clean, and moving the cars on the track. The rails are butted against each other, and two chucks are welded from either side across the joint. These chucks are not only welded to both of the rails, but, by the lateral pressure exerted against the heated ends of the rails, force the latter into each other.

METALS, ALLOYS AND COMBINATIONS OF DIFFERENT METALS ACTUALLY WELDED BY THOMSON'S PROCESS.

METALS.

Wrought Iron	Wro't Copper	Tin	Cobalt	Aluminum	Gold (Pure)
Cast Iron	Cast Copper	Zinc	Nickel	Silver	Manganese
Malleable Iron	Lead	Antimony	Bismuth	Platinum	Magnesium

ALLOYS.

Various Grades of tool Steel	Musshet Steel	Wrought Brass	Fuse Metal	Aluminum Alloyed with Iron	Silicon Bronze
Various grades of mild Steel	Stubs Steel	Cast Brass	Type Metal	Aluminum Brass	Coin Silver
Steel Castings	Crescent Steel	Gun Metal	Solder Metal	Aluminum Bronze	Various Grades Gold
Chrome Steel	Bessemer Steel	Brass Composition	German Silver	Phos. Bronze	

COMBINATIONS.

Copper to Brass	Brass to Wr'ght Iron	Brass to Tin	Wrought Iron to Tool Steel	Wr'ght Iron to Musshet Steel	Wr'ght Iron to Nickel
Copper to Wrought Iron	Brass to Cast Iron	Brass to Mild Steel	Gold to German Silver	Wrought Iron to Stub Steel	Tin to Lead
Copper to German Silver	Tin to Zinc	Wrought Iron to Cast Iron	Gold to Silver	Wr'ght Iron to Crescent Steel	
Copper to Gold	Tin to Brass	Wrought Iron to Cast Steel	Gold to Platinum	Wrought Iron to Cast Brass	
Copper to Silver	Brass to German Silver	Wrought Iron to Mild Steel	Silver to Platinum	Wr'ght Iron to German Silver	

Experience has established the following facts: A continuous 70-pound rail requires about 150,000 pounds strength to withstand the maximum strain put upon it longitudinally by the variations in temperature from coldest winter to hottest summer. An electric weld will only break at 279,000 pounds strain. Four joints can be made in an hour, under proper conditions. The electric conductivity of the joint is as great as the rail itself. Figure 11 shows the appearance of a weld.

In concluding this article I feel that I have been unable to do justice to the subject, it being too large a one to be treated in detail in a single article. It will serve, however, to draw the attention of the engineer to the practical work accomplished, but the future possibilities are hard to predict in view of the general growth of engineering in the past.

To sum up, electric welding has these indisputable advantages:

The heat is sharply localized to the joint and metal near it.

The temperature obtained and required can be exactly regulated.

The rapidity of heating and its distribution can be controlled by simple means. Irregular forms can be welded in the desired relation of its various parts.

By this process all metals, as well as the alloys of all metals, are weldable.

The welding operation is carried on under the direct inspection of the operator.

The operation can be and often is made automatic, and the result is absolute uniformity; oxidized surfaces are excluded from the joint, and only clean metal unions made.

Pieces can be welded to exact size, and finished pieces may retain their finish during welding.

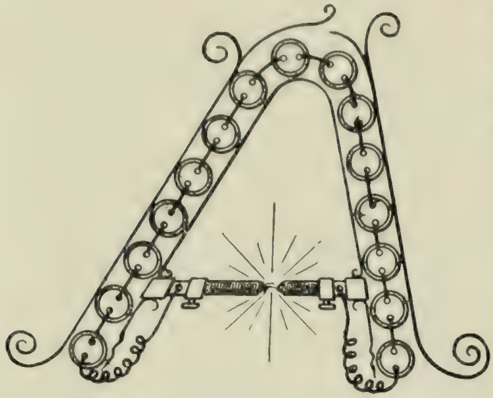
The process may be applied to pieces in place, as in track-welding. Water-power may be employed for the work, or the cheapest fuels of lowest grade.

The greatest convenience and cleanliness attends the practice of the process.

The cost of fuel is not greater and generally less than in forge-welding, while the labor is reduced one half.

BEGINNINGS AND FUTURE OF THE ARC-LAMP.

By S. M. Hamill.



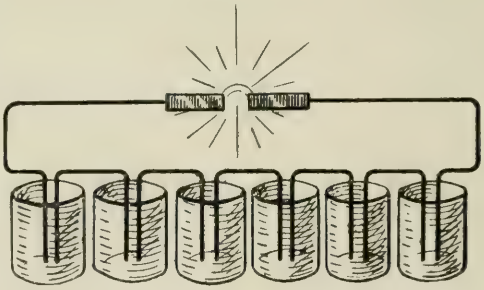
ARC-LIGHTING may properly be divided into three periods: that prior to 1876; that between 1876 and 1894; and that of the future. In 1810 Sir Humphry Davy produced an arc-light, his description of which was as follows:

"Pieces of charcoal about one-sixteenth of an inch in diameter whose ends are connected to a source of electric current, are brought near each other (within $\frac{1}{32}$ or $\frac{1}{40}$ part of an inch) a bright spark is produced, and by withdrawing the points from each other a constant discharge takes place through the air, producing a most brilliant ascending arch of light, broad and conical in form in the middle; hence the term 'arch light,' commonly called 'arc light.'"

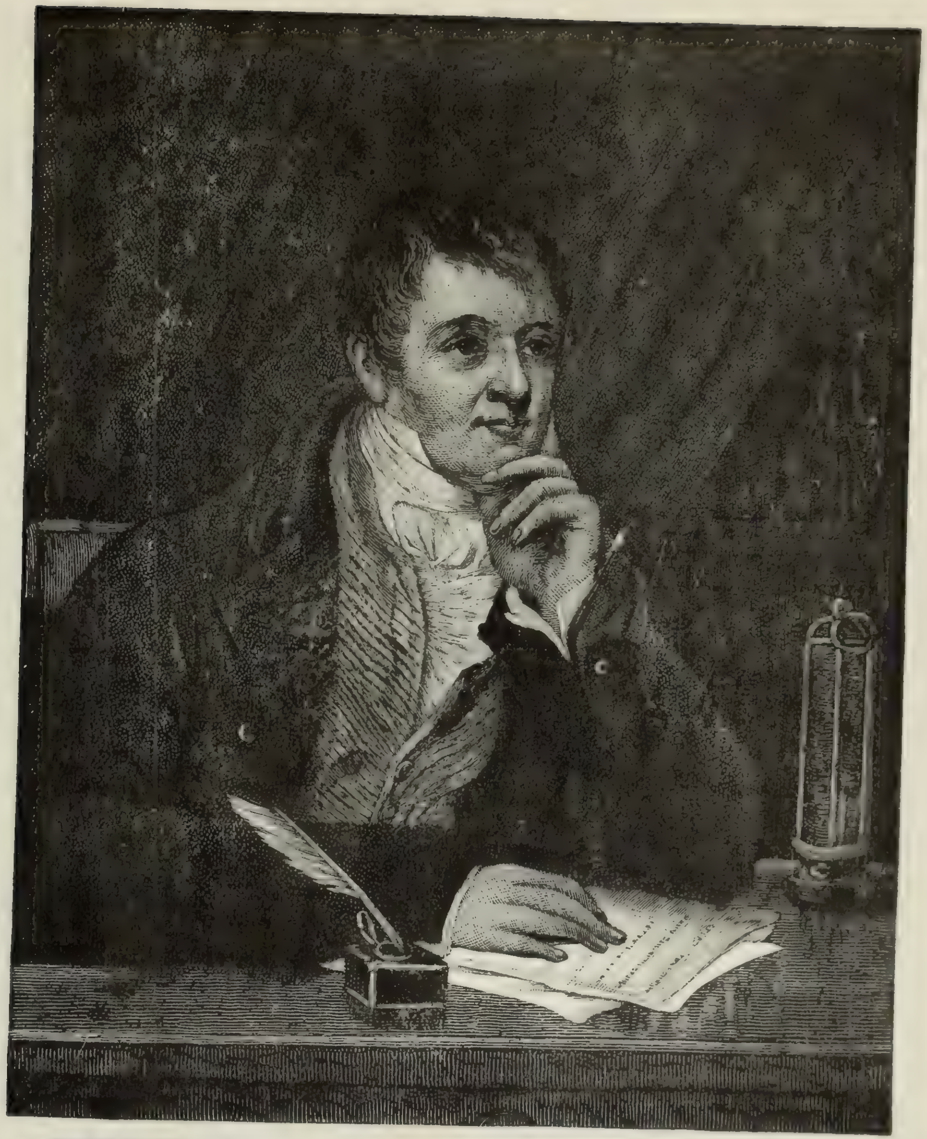
This remained an interesting laboratory experiment until the year 1844, when Leon Foucault replaced the soft charcoal with the hard carbon found in gas-retorts, and, availing himself of the use of the newly-invented battery of Professor Bunsen, succeeded in producing steady, continuous, and brilliant light.

With batteries as the only available source of electric current, commercial arc-lighting on a large scale was impossible until after Faraday's and Henry's wonderful discovery of magneto-induction. Many arc-lamps of more or less merit were invented, but, with few exceptions, they were abandoned, among the most successful ones being the Serrin and Duboscque.

Among the lamps which attracted considerable attention was the Jablochkoff candle. Owing to the unsteady working of the mechanism of laboratory lamps for feeding the carbons, Jablochkoff conceived the idea of placing the two carbons parallel to each other at a fixed distance apart, and, as with the direct current the positive carbon was consumed approx-



FIRST ARC-LIGHT.



Your Obt humble Servt

H Davy Pres RS*

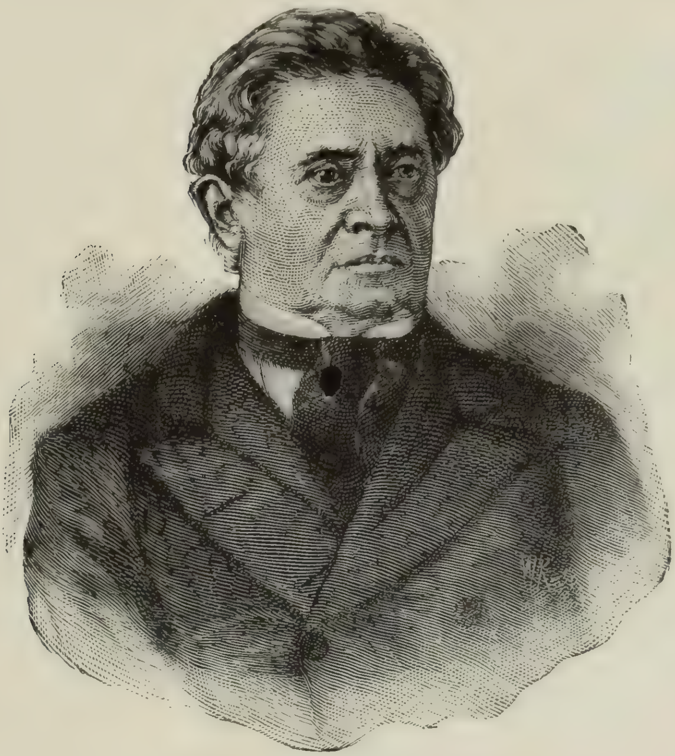
SIR HUMPHRY DAVY.

[By courtesy of *Scribner's Magazine.*]

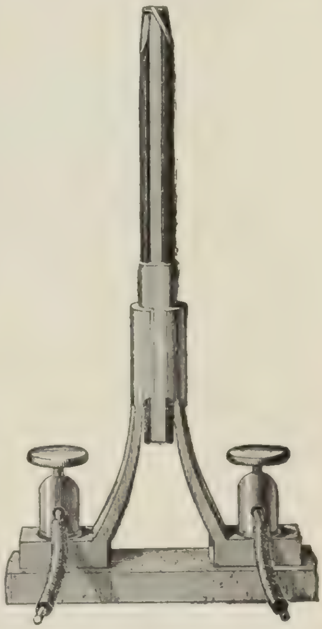
FARADAY SHOWING HIS EXPERIMENTS TO HIS WIFE.

[By courtesy of *Scribner's Magazine*.]

imately twice as fast as the negative, he used an alternating current, thus overcoming this difficulty. The system itself soon became obsolete on account of the introduction of series arc-lighting.


PROFESSOR JOSEPH HENRY.

For sixty-six years, therefore, few, if any, practical results accrued to the world from this laboratory experimenting. In 1876 hardly an arc-light was burning; not a store, factory, shop, foundry, or street was lighted by electricity. The development of arc-lighting and the kindred development of incandescent lighting and the distribution of the electric current for power are the marvels of this age of electricity into which we have just fairly entered.


JABLOCHKOFF CANDLE.

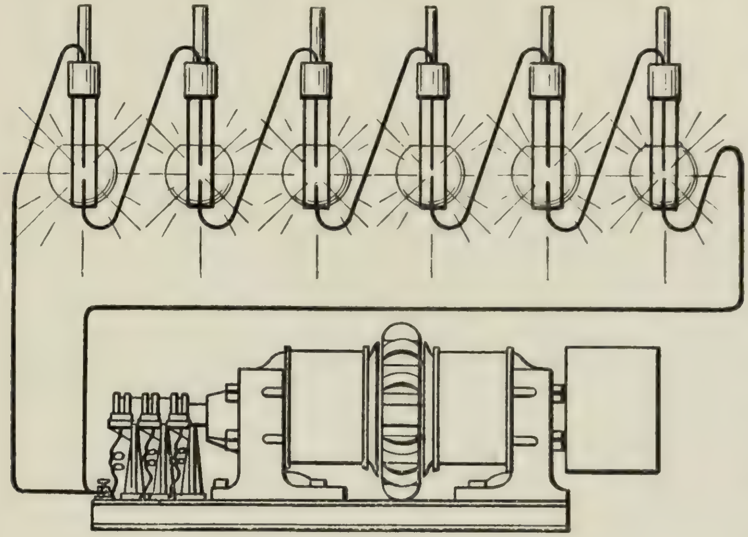
During the year 1876, Charles F. Brush, a young man of twenty-seven years, began his practical electrical work, the results of which aroused such wide-spread interest throughout the world, and subsequently gave such an impetus to the electric-lighting business as well as to the whole field of the distribution of power by electricity. He was fortunate in having able, energetic, and conservative business-men associated with him.

Mr. Brush, while a youth on his father's farm in Euclid township, Ohio, became greatly interested in the subject of electricity. He entered the Shaw Academy at Collamer, Ohio, at the age of thirteen. While there his first experiments with static electric machines and with electromagnets and batteries of his own construction were made. From the village blacksmith he secured old pieces of iron for use

CHARLES F. BRUSH.

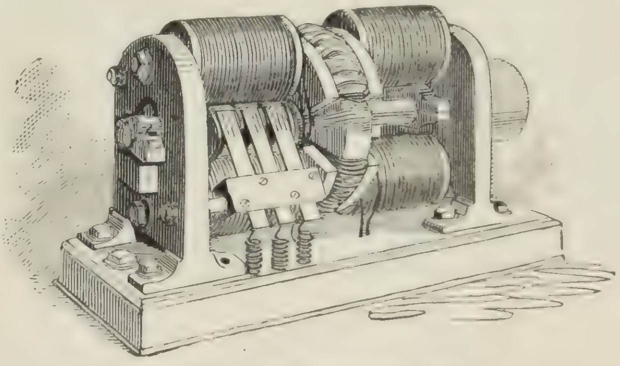
in his boyish experiments. He subsequently entered the Cleveland High School, from which he was graduated with high honors in June, 1867. During his senior year the physical and chemical apparatus belonging to the school was placed in his charge. Some of the inventions in electric-lighting which he has since developed were the outgrowth of these school-boy experiments. His graduating oration on the "Conservation of Force" outlined much that has been accomplished in the past few years. After graduating from the Cleveland High School he entered the University of Michigan at Ann Arbor, from which he was graduated in 1869, one year ahead of his class, with the degree of Mining Engineer. He subsequently received the degree of Ph.D. from his alma mater.

Returning to Cleveland, he organized a laboratory and conducted the business of an analytical and consulting chemist for about three years. In the spring of 1873 he entered the iron business. He still, however, even though in business, devoted a great deal of thought and time to electrical investigations, and early in 1876 completed his first dynamo-electric machine. This dynamo was of a distinctly new type, and embodied the first of Mr. Brush's long series of brilliant investigations which have made him wealthy and famous the world over, and so perfect was it that it has never been out of order since. Either the first dynamo, or one of the very first, similar to it, was running until it was purchased quite recently for exhibition at the World's Fair in Chicago.



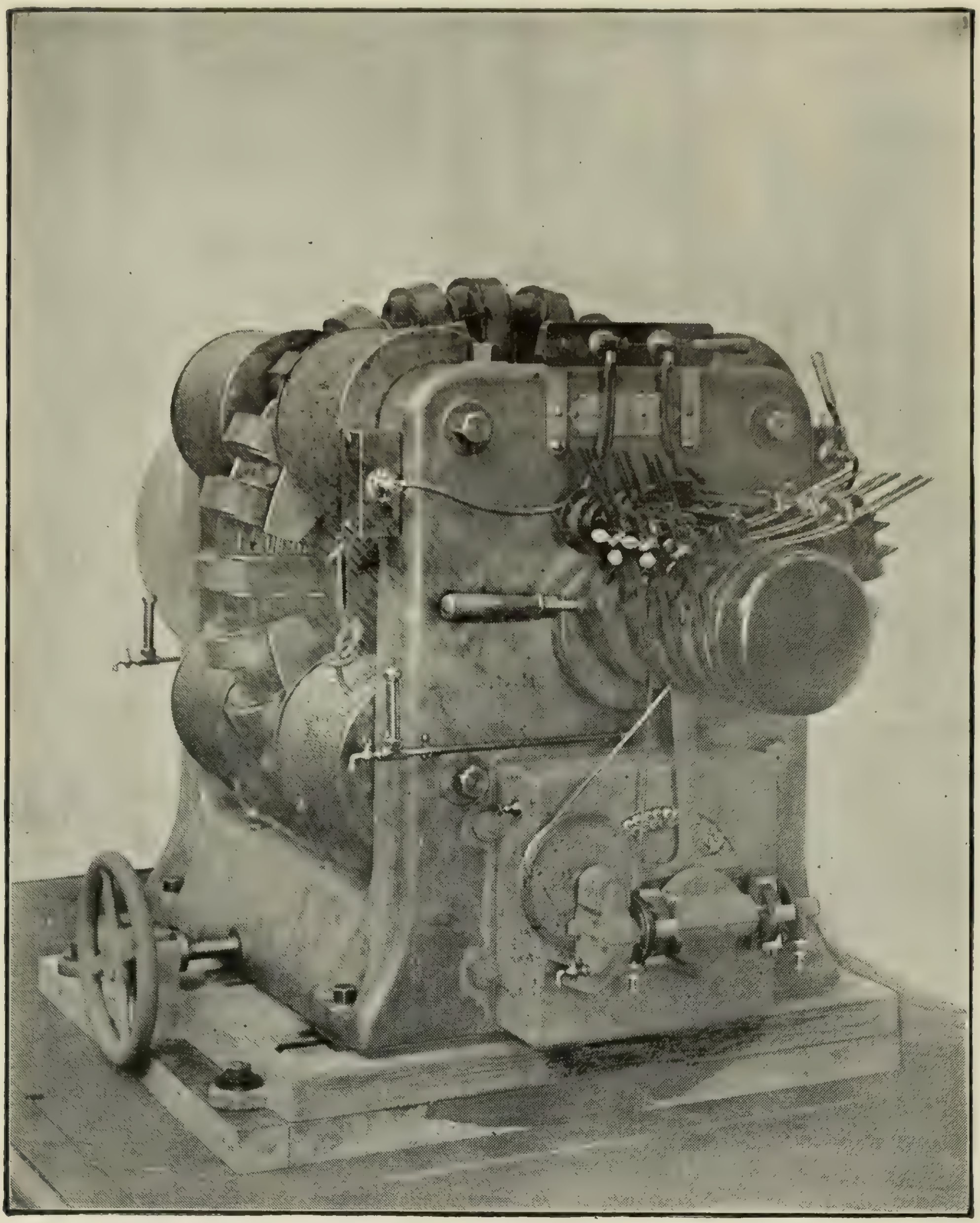
SERIES ARC-LIGHTING.

Mr. Brush's thorough knowledge of both electricity and mechanics, coupled with his ability and genius, enabled the Brush Company to make more profit from the legitimate manufacture and sale of electric-lighting apparatus than any competitor. A young man who enters the business to-day, with a thorough knowledge of electricity and with little knowledge of mechanics, is not of much value to the manager of a factory or an electric-light or -power station. The lack of knowledge of electricity on the part of mechanical engineers and of mechanics on the part of electrical engineers has been the cause of great loss to the manufacturers of electrical apparatus.



FIRST BRUSH DYNAMO, 1876.

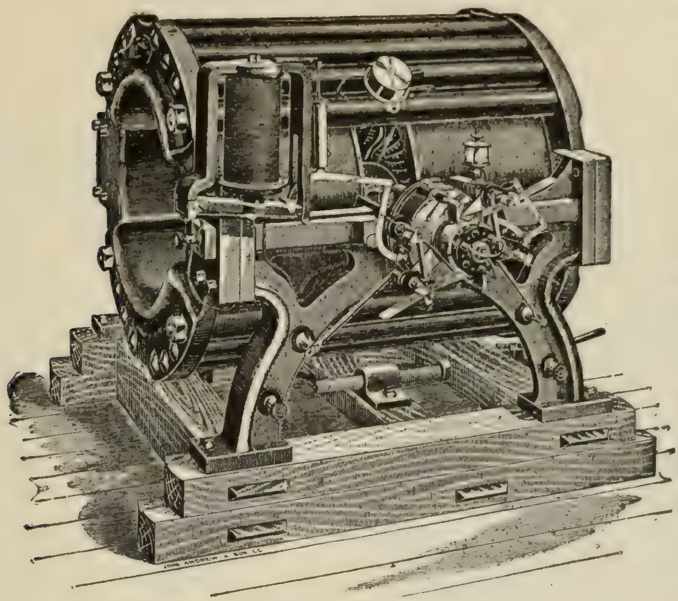
Mr. Brush experimented comparatively little. After deciding on the best methods to persue, the next step was to make a complete working drawing, with full details, ready for the pattern-maker. The whole problem had been so thoroughly worked out in his mind that in nearly every instance the first machine or piece of apparatus made from his drawings was found to be perfect in every detail and ready



150-LIGHT BRUSH ARC-DYNAMO, WITH GOVERNOR.

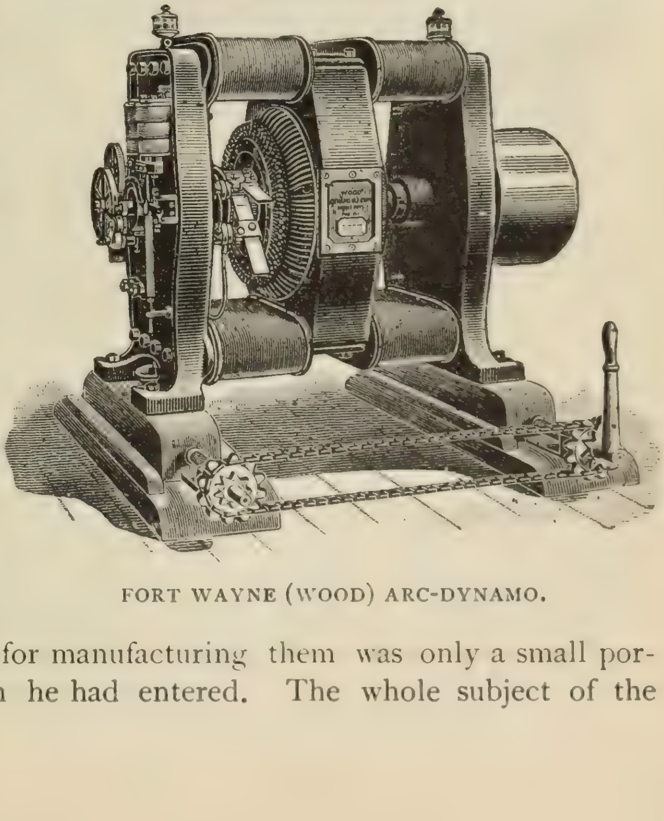
for practical use. This peculiar ability to work out and construct his apparatus on paper, and, as it were, to have a mental picture of it before it was erected in the shops, made him an ideal inventor and designer for a manufacturing company. This characteristic saved his company thousands of dollars in experimenting and enabled them to pay him in royalties upwards of $400,000 on the business of a single year.

When he first designed and constructed his arc-lighting apparatus, and the manufacture of it began on a large scale, the state of the art of dynamo- and lamp-construction was entirely undeveloped. Shop machinery and tools for the manufacture of electrical apparatus were unheard of, and it became necessary to design them for this purpose. Being an accurate and skillful draftsman and mechanic, and perfectly at home in the use of tools for both wood- and metal-working, he devoted much time to the designing and building of machinery in order to manufacture his apparatus. Many of the machines and tools suggested and designed by Mr. Brush are widely used throughout the world in the factories where they manufacture electrical apparatus. All the machinery, tools, and methods for making and copper-coating electric-light carbons and manufacturing storage-batteries were very largely originated by him.



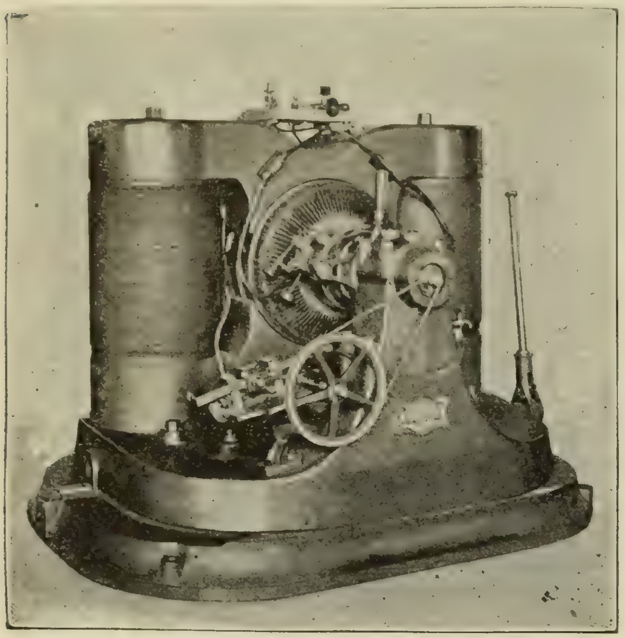
THOMSON-HOUSTON ARC-DYNAMO.

The subject of insulation—such a vital point in modern dynamo-construction—necessarily received a great deal of his attention, and his methods are widely used to-day. The designing of dynamos and construction of machinery and tools for manufacturing them was only a small portion of the field which he had entered. The whole subject of the



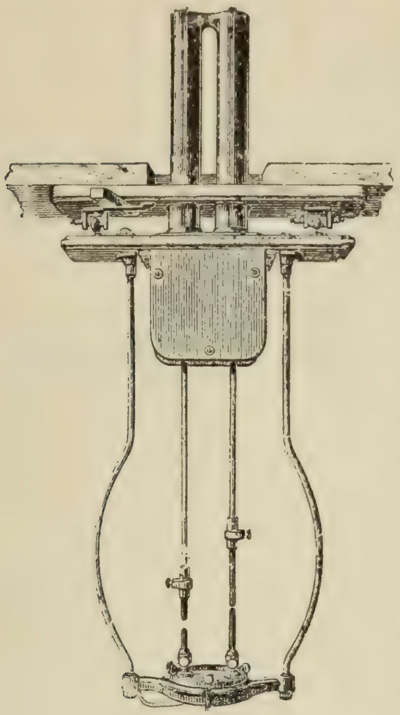
FORT WAYNE (WOOD) ARC-DYNAMO.

proper method of distribution of current for electric-lighting was before him. The dynamo and lamp were built, but the measuring instruments, the electric-light stations, involving questions of boilers, engines, proper construction, governing and erection, were questions to which he gave a vast amount of his time. The first electric-light stations in the world used Mr. Brush's apparatus and, necessarily, when the erection of a station was under consideration, he was consulted and his plans followed. The whole field, therefore, of the conception, designing, and construction of electric-lighting apparatus; the planning of the factory; the designing of new tools and machinery for manufacturing the new and unheard-of articles; the best methods for testing, boxing, and shipping the apparatus; the planning and laying out of the electric-light stations; the arranging of the switchboard and electric-light circuits, which were to run from the station in innumerable directions; the best methods of erecting the pole lines and lamps in order to avoid risk of fires; the best methods for insulating wires, which at that time was so difficult to secure as to lead Mr. Brush to design complete machinery for insulation in the Brush factory—were all difficult and unsolved problems, to which he gave hourly thought and attention during all the early years of the development of the business. This was done at a time when there were absolutely no precedents and no one to follow. It meant hours of toil and care; it meant work at the factory before the workmen arrived in the morning, and work in the laboratory after the day's work of others was done.



STANDARD (SPERRY) ARC-DYNAMO.

The first of the large arc-dynamos of 1893 was started in one of the large electric-light stations and has since been running regularly. The machine was built from the original windings and designs, notwithstanding that the construction of a 7000-volt constant-current arc-dynamo is one of the most difficult problems of the day in dynamo-construction, and in 1876 was considered an impossibility. These facts indicate the characteristics of the man to whom we all in the electric-light business owe so much, and to whom is due largely the modern complete methods for the generating and distributing of the electric current for lighting.

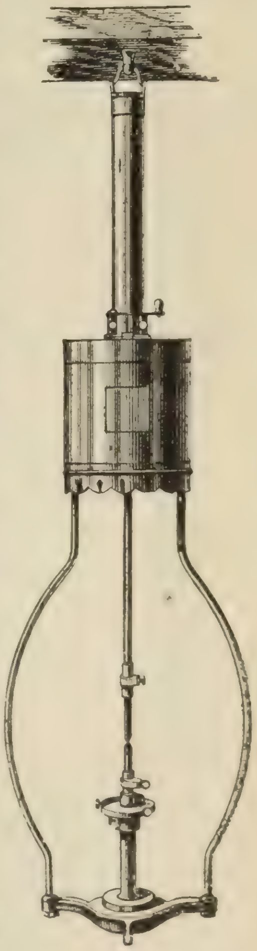


DOUBLE ARC-LAMP.
[For Outdoor Lighting.]

When a majority of the directors of the old Telegraph Supply Company of Cleveland (subsequently the Brush Electric Company) reported to the manager that Brush was spending considerable money in trying to devise a system of electric-lighting ; that they thought he was working in a field without a future and that it was better to confine themselves to their legitimate business—the manufacture of telegraph instruments and electric bells — they did not have the same conception that Mr. Brush had of the possibilities of the future. The apparatus was built and the system devised, but the problem of persuading the public to purchase and use it was unsolved. The small dynamos and lamps exhibited at the Franklin Institute, at Philadelphia, and the Mechanics' Fair, in Boston, were great advertisements.

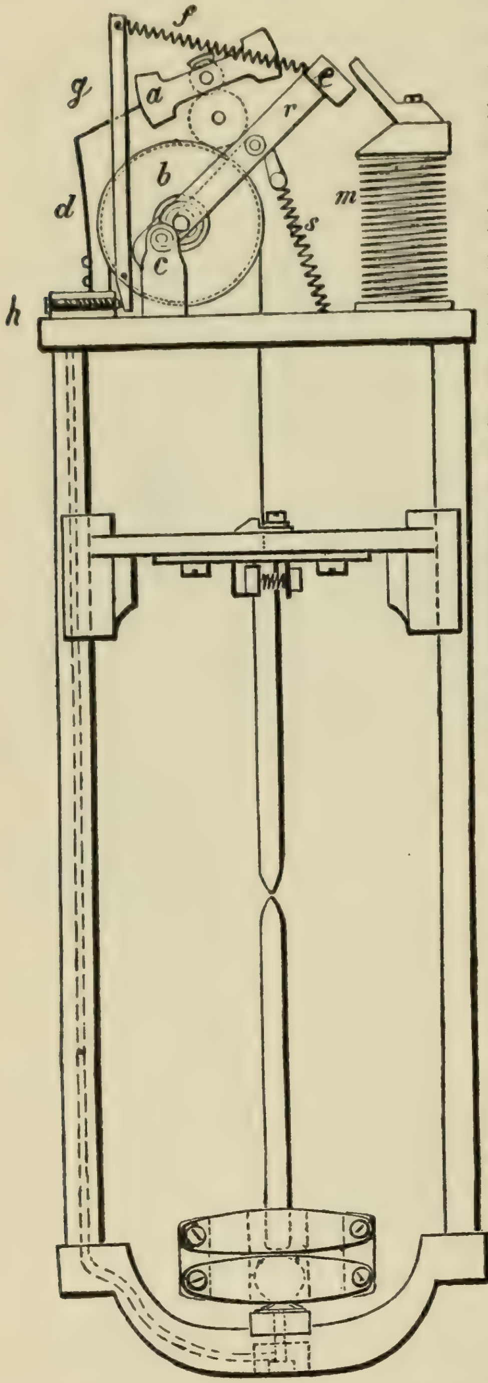
The original dynamos and lamps were sold for use in factories. The large woolen- and cotton-mills of New England became a great market. Many of these mills are lighted to-day with Brush apparatus sold prior to 1880.

The idea of the central electric-light station was of subsequent growth. The first public places lighted were those surrounding the court-house in Wabash, Indiana, and the water-tower in Chicago. The public square in Cleveland was lighted by a number of arc-lights, which replaced all the gas-jets on the square at the same cost of lighting to the city. This arrangement was one of the first, if not the first, made with any municipal authority



SINGLE ARC-LAMP.
[For Indoor Lighting.]

for street-lighting. The idea of a central station originated in San Francisco. One of the first electric-light companies started was organized in New York by several influential capitalists of that city, largely interested in New England mills. This was in 1879. The station was started on Christmas night of 1879 and Broadway, from Fourteenth to Thirty-fourth street, was illuminated by arc-lights. The Albany, Philadelphia, Baltimore, Boston, Rochester, and Buffalo electric-light companies, which to-day have millions of dollars invested in their plants, with thousands of lights burning nightly, were started shortly thereafter and largely by the same gentlemen and their friends. These were the first of the hundreds of electric-light stations now scattered all over the world. The city of Manila, in the Philippine islands, is just completing a station of 10,000 incandescent and 300 arc-lights. Nearly every town of over 5000 inhabitants in the United States has its electric-light station, and a large number of smaller towns are lighted by electricity.

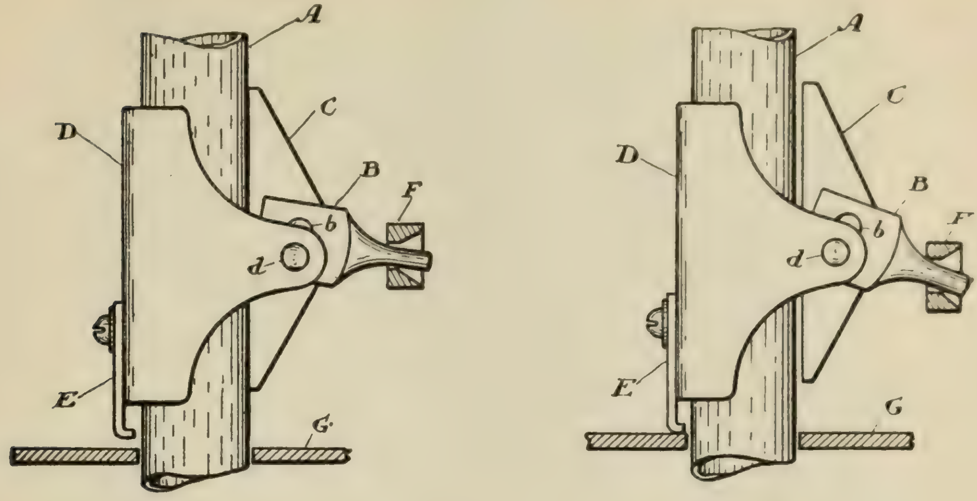


SIEMENS & HALSKE RATCHET ARC-LAMP.

[Ribbon-Feed Type.]

One manufacturing company has produced in its factory upwards of 150,000 arc-lamps and 5000 arc-dynamos. These lamps are burning all over the world. Another company has manufactured 100,000 lamps. Four hundred thousand arc-lamps is a fair estimate of those burning to-day.

Only a few years ago there was not an electrical engineering school in the country. During this year 1500 young men will be graduated from the electrical engineering schools, equipped for the business.



[Fig. 1.] [Fig. 2.]

RECENT CONSTANT-CURRENT LAMP OF THE CLUTCH TYPE.

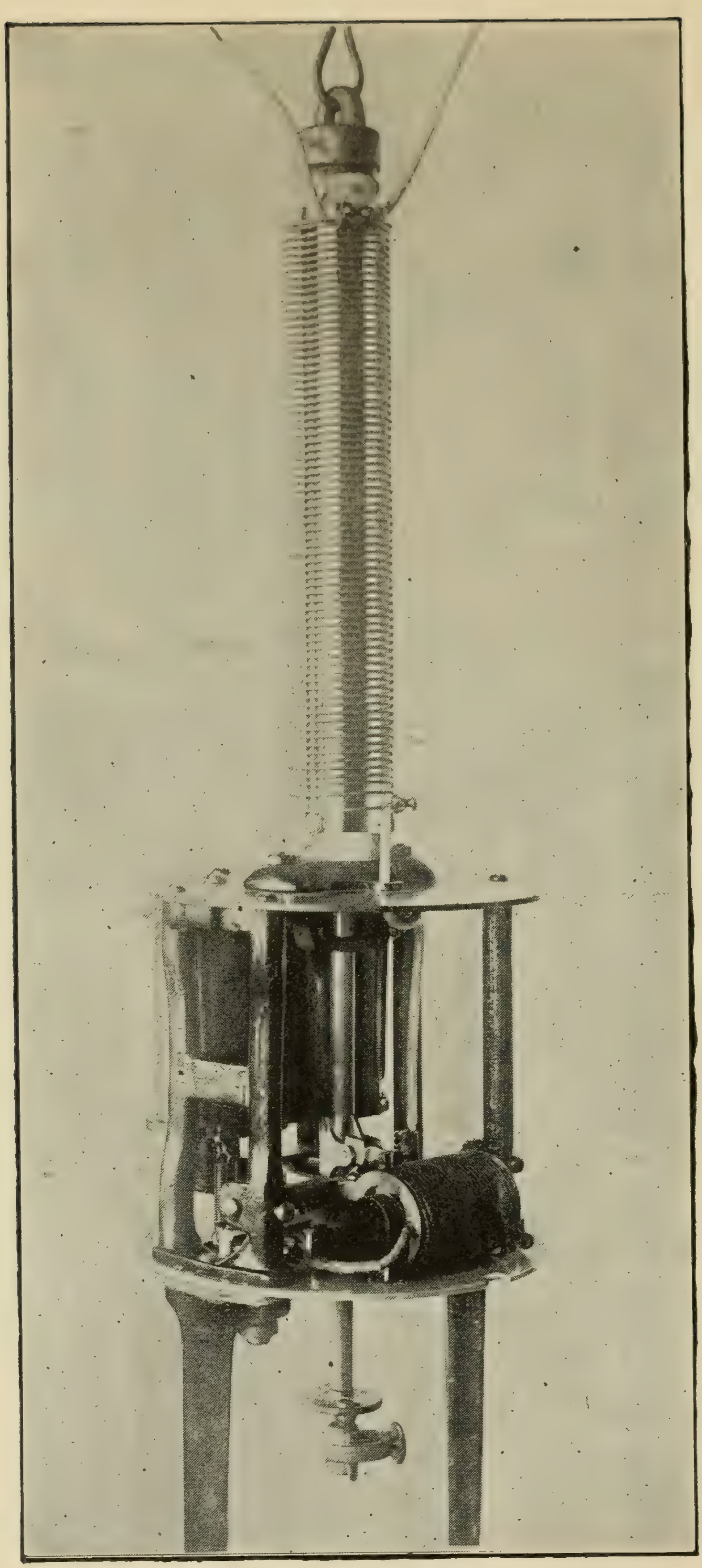
In 1883 the Brush factory turned out 5,000,000 carbons, and in 1893, 26,000,000. Prior to 1883 carbons were sold at from $70 to $80 per thousand, and in 1893 at from $10 to $12 per thousand. The National Carbon Company are just completing a factory in Cleveland, composed of fourteen large buildings, covering seventeen acres, practically under one roof. This factory is for the sole purpose of manufacturing carbons, and it has a capacity of 2,500,000,000 per year.

Shortly after Mr. Brush became interested in the electric-lighting field, many others also began their practical electrical work, among them being Elihu Thomson, Edward Weston, Hochhausen, Houston, Wood, and others in America, and Siemens and others in Europe, who produced systems of more or less merit. These various dynamos and lamps have generally been named after their designers.

The different methods of the construction of arc-dynamos is an interesting study. Scores of electricians have, with the aid of the draftsman, pattern-maker, and the paint pot, made their various dynamos appear as different as day is from night.

To build an arc-dynamo that will produce currents of electricity is not difficult, but to design a dynamo highly efficient, mechanically perfect, thoroughly ventilated, easily repaired, absolutely self-regulating, with careful regard to economy in material and labor is another problem.

Most armatures, and, therefore, perhaps most dynamos, are of the Siemens, Gramme, or Brush type, whether they be the toy dynamo for a Christmas present to the young, or the great dynamos such as were used at the World's Fair or are being constructed for Niagara Falls. The dynamos invented by Mr. Brush and Messrs. Thomson



MECHANISM OF RECENT CONSTANT-POTENTIAL ARC-LAMP.

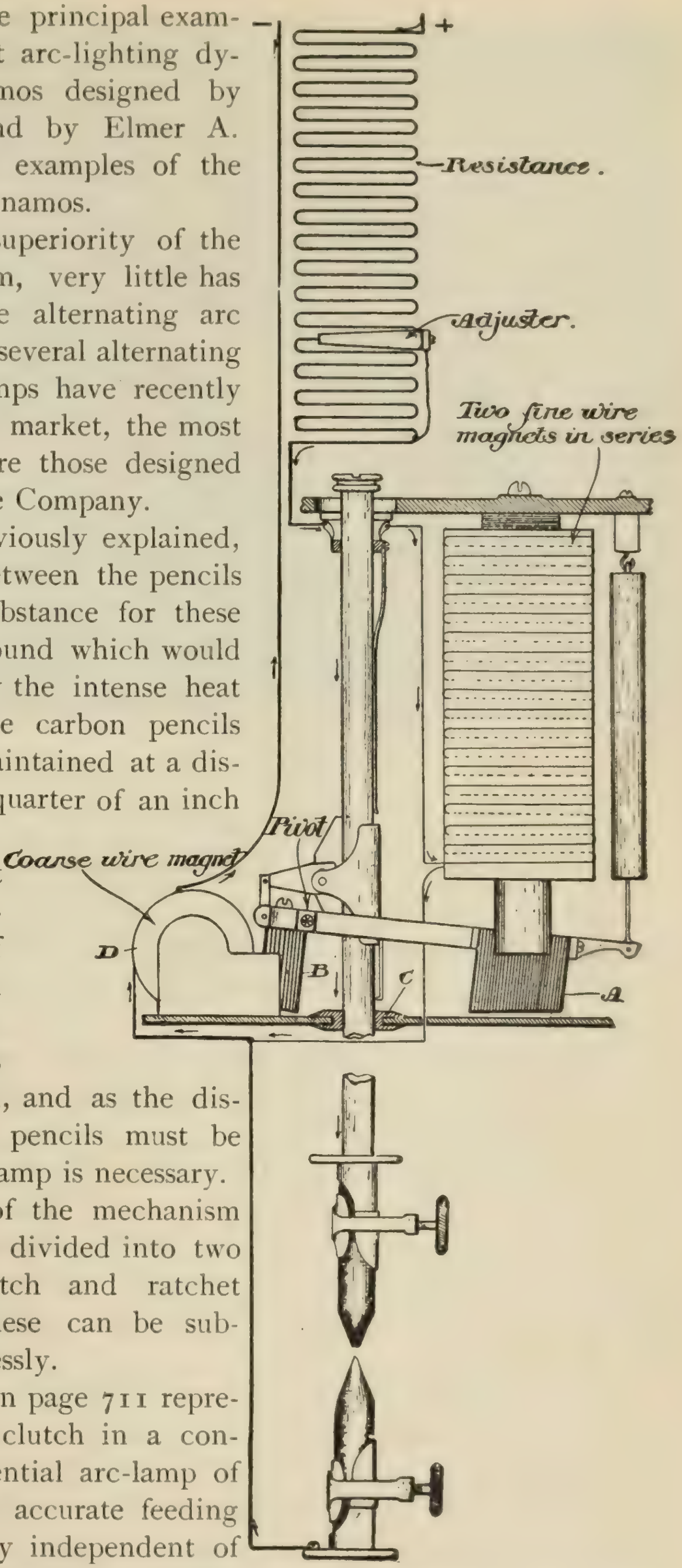
and Houston are the principal examples of open circuit arc-lighting dynamos. The dynamos designed by James J. Wood and by Elmer A. Sperry are notable examples of the closed-circuit arc-dynamos.

Owing to the superiority of the direct-current system, very little has been done with the alternating arc system. However, several alternating arc-dynamos and lamps have recently been placed on the market, the most notable of which are those designed by the Westinghouse Company.

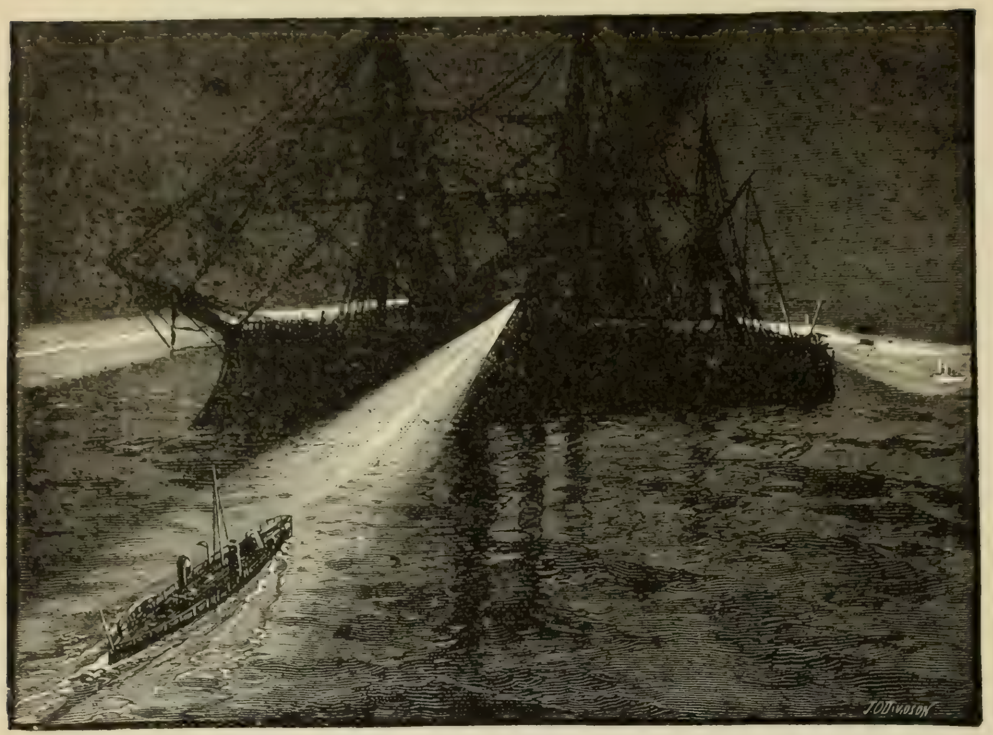
As has been previously explained, the arc is formed between the pencils of carbon. If a substance for these pencils could be found which would not be consumed by the intense heat of the arc, and the carbon pencils could always be maintained at a distance of about one-quarter of an inch from each other, then the somewhat delicate and complicated mechanism of an arc-lamp would be unnecessary. No such substance has as yet been discovered, and as the distance between the pencils must be maintained, an arc-lamp is necessary.

The principles of the mechanism of arc-lamps may be divided into two general classes, clutch and ratchet feed-lamps, and these can be subdivided almost endlessly.

The two figures on page 711 represent a very modern clutch in a constant-current or potential arc-lamp of the clutch type, the accurate feeding of which is entirely independent of the cleanliness of the carbon rods.



CONSTANT-POTENTIAL ARC-LAMP.



ELECTRIC SEARCH-LIGHT.

This result is accomplished by not allowing the rod *A* to slide, but by gripping it (Figures 1 and 2) and holding on until the trip *E* reaches its lowest position on *G*, when it suddenly releases and takes hold further up. This action is so rapid as not to affect the steadiness of the light, an air dash pot preventing any sudden movement in a downward direction.

The improvements in instruments and switchboards for stations have been very great and the most modern are not only ornamental, but have reached a very high degree of perfecion.

The future of the arc-light is secure. To state more than this is speculation. What the younger Brushes, Thomsons, and Edisons will accomplish cannot be definitely stated. Probably for a few years it will be along the line of improvements in present methods and machinery, after which genius may present us with new and astonishing changes.

The arc-dynamo will be made in larger units. A growing opposition to overhead wires leads central-station men to increase the number of lamps on each of their already existing circuits. The high rate has a like tendency for rental of underground conduits. A few years ago a dynamo of a capacity of ten amperes and fifteen hundred volts (thirty arc-lights) was considered a wonder and dangerous. To-day many are running of the capacity of ten amperes and seven thousand volts (one hundred and fifty lights). The whole tendency, not only in arc-lighting, but in the distribution of power, is toward larger machinery and higher potential. The arc-lamp itself will be simplified and beautified, but its general construction will change little.

As in the past, the engine- and boiler-manufacturers will do their part in the improvements of their engines and boilers along the line of lower cost of manufacture and in higher efficiency. Central-station managers will do their portion in accomplishing improvements by demanding from the manufacturers cheaper, larger, better, more economical, and more efficient apparatus.

The great problem for the future lies in the management of local electric-light companies. In these modern times, it is little we care for glory. Dividends are the cry of the hour. How to earn them is the problem. There are in this country three large arc-light stations under one management in a city of 500,000 inhabitants, earning from 12 to 15 per cent. on the actual cost invested. An electric-light station in another town of 12,000 people earns about the same. Both of these companies are operating under ordinary conditions. A company in a city of 40,000 inhabitants, using certain machinery, with a valuable city lighting contract, lost money and failed. Another company, with the same machinery, but under different and very conservative and economical management and with a much lower contract for lighting with the city, earns from 15 to 20 per cent. on the actual investment. A company in a town of 5000 people became bankrupt and was sold at a receiver's sale. New management, practically under the same conditions, earned satisfactory dividends for the stockholders.

These examples would indicate that there is large remuneration from such investments, notwithstanding the fact that a large number of electric-light companies in the country have lost money. It is not so much a question of engines and boilers and dynamos and lamps, as of management. It is not so much a question of cheap machinery as of management.

Cleanliness in a station and on the circuits is essential. Dirt, grease, and filth scattered about are a sure indication of running behindhand. A neat station, dynamos, and lamps and engines and boilers, always clean and in good order, the poles and circuits well kept up, uniform rates of lighting, based on a fair margin of profit, a good and regular light every moment of the year, courteous and fair treatment to customers, insure success and dividends.

Arc-lighting as a business has been developing for eighteen years; incandescent lighting for thirteen years; and the distribution of power for stationary and street-railway motors for nine years. The future development of the distribution of the electric current for incandescent lighting and power and for heating will be almost beyond comprehension. However, this does not prove that the arc-light has seen its best day and that its use will decrease. On the contrary, there will be more arc-lamps sold during the next fifteen years than during the past fifteen years. The arc-light is preferable for lighting large areas. Its field is in the factory, in large stores, and in our streets.

The arc-lighting of city streets is in its infancy. New York has 2750 2000-candle-power street lights; 6000 would hardly light the city. Brooklyn has 2200 lights; it will require 3000. Chicago has 1300; 7000 are needed. Buffalo has 2000 and requires 4000. Boston will shortly have 2300 and should have twice as many. The city of Cleveland has 245; 3000 will be insufficient. The city of Detroit has just purchased 1500 arc-lamps as a starter for lighting the whole city by electricity; they will need twice as many within a year or two. Comparatively little street arc-lighting is done in the large cities and towns. Ten times as many arc-lights will be used in two or three years, for street lighting, as are used to-day.

Street gas-lamp posts and the oil-lamp posts must go. They have outlived their usefulness. They are to the arc-lamp as the moon is to the sun. Our streets are lighted purely for safety and convenience. The powerful and penetrating rays of the arc-light tend to lessen crime. The future, therefore, of the arc-light is not an uncertainty, although in comparison with the growth and development of its younger sisters and brothers, much less will be heard about it, but more will be seen by it.

THEATER-BUILDING FOR AMERICAN CITIES.

By Dankmar Adler.

FIRST PAPER.

OCCASIONALLY a theater is so constructed that the eye and ear of every person in the audience can easily follow the performance on its stage; that its means of ingress and egress and of internal communication are easy and commodious; its ventilation such, that the air does not become pestilential before the close of each performance, and its decorative treatment neither vulgar nor tawdry. The designer of such a house is thought to have accomplished a most remarkable and noteworthy feat, and architects and laymen join in expressing doubts of the possibility of repeating so unusual and unexpected a success.

It is my good fortune to have been the architect of several successful theaters and public halls, and to be among those who have experienced the treatment above indicated; and yet I feel myself justified in maintaining that success in theater building is no more difficult of achievement than in any other branch of architectural practice, provided one's action is based, not merely upon recorded precedent and tradition, but also upon extensive and careful original observation and independent thought. For these reasons I shall not make this article a repository of historical information about the theaters of the past, nor a description or critical disquisition upon the theaters of the present day, nor yet a compendium of scientific formulæ for solving the various problems of theater-design. With a view to stimulating original and independent thought and action, I shall call attention to certain facts and conclusions, the recognition and formulation of which are within the reach of every intelligent observer and of every industrious student of objects and events.

If every theater-goer could build his own theater, theater-building would have become as familiar and as easy of successful accomplishment as house-building, and the mental processes of the theater designer which determine success or failure would no longer be regarded as occult and mysterious. But theaters are comparatively few in number, and while each theater counts its patrons by the thousands, only few of these can ever have a personal financial interest in or influence upon its erection or management, or become acquainted with the details of its construction, equipment, and operation. Therefore, public opinion upon theater plan and construction has never been clarified or crystalized, and theaters have been and probable will be constructed rather as the embodiment of the views of a very few immediately interested parties than as expressing the wishes of the great theater-going public.

The architect can hardly be expected to ascertain by direct intercourse with each individual theater-goer what the public really demands of its theaters; but he has opportunities for observing the conduct of the mass of the people toward theaters, and of deducing from this conduct what the people want. Upon taking note of the relations of the theater-going public in the cities where there are many theaters between which to choose, the first impression forced upon the observer is, that the public will go into any house which presents upon its stage a sufficiently potent attraction. No matter if the house be a notorious fire-trap; no matter how steep and incommodious the stairs leading to the different parts of the auditorium; no matter how narrow the aisles; no matter how promotive of torture the positions into which form and arrangement of seats force their occupants; no matter how vile its odors; no matter if the acoustic qualities of the auditorium are such that only by the most constant and close attention is it possible to follow the words of the play; no matter how vulgar and tawdry or how weak and expressionless the decorative treatment of the house,—if a well-known and popular attraction is presented upon the stage, it will play to crowded houses. On the other hand, theaters and opera houses in which the construction and equipment are most thorough, and in which the utmost regard has been paid to the comfort and safety of every member of the audience are not filled unless the attraction upon the stage is of the first quality, while inferior attractions will always play to empty benches.

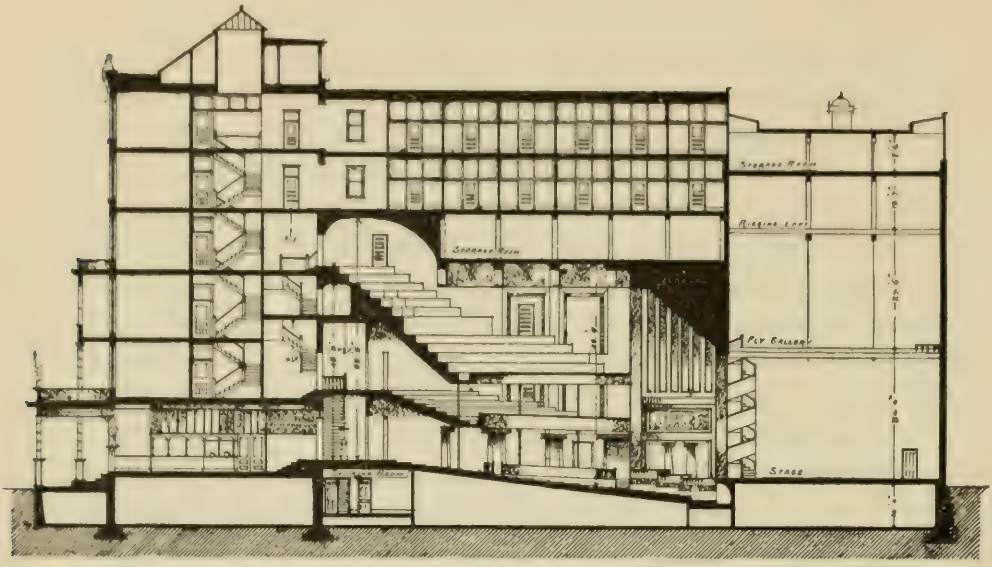
In America theaters are not considered, as in continental Europe, quasi-educational institutions maintained by state and municipal governments; but almost invariably they are ventures for pecuniary gain, and the purpose which governs their projectors, owners, and managers, to which the architect must necessarily subordinate himself, is apt to be that of drawing to their seats the greatest possible number of people with the smallest possible outlay for construction, equipment, and maintenance.

But fortunately the conditions of competition are often such that broader selfishness sees in a liberal, sometimes even in a lavish, outlay, the means for obtaining returns proportionately greater than those following a parsimonious policy. It may be safely assumed that if the public will attend in large numbers to see a fine play well rendered in an ill-constructed theater, still larger numbers will flock to well-constructed and well-equipped theaters to see the same kind of performance.

As box-office receipts indicate that the interest of the theater-going public centers in the stage performance, the architect of a theater will first concentrate his attention upon the stage and its adaptation to the productions to be presented. Next in order would come the effort to eliminate from the design of the auditorium everything which tends to restrict the full enjoyment by the audience of the stage performance, and the development of everything which tends to add to that enjoyment. Ease and convenience of approach are probably next among the good qualities of a theater which are recognized by the public, while solidity of construction and limitation of danger by fire are apparently the last points of superiority appreciated by the public, and therefore most often ignored by owners and managers.

I shall endeavor to sketch the lines of development which should be followed in designing the average American theater, built for the purpose of earning a reasonable interest upon its cost, and managed upon the lines prescribed by a broad business policy, which seeks not only to cater to the expressed wishes of existing patrons, but endeavors continually to increase their number by striving to learn whether the public may not have latent wants and wishes as yet unexpressed and undiscovered, by catering to which the management may derive further profits.

It is natural to assume that the larger and better equipped the stage the better will be the performances upon it, and therefore the greater the drawing power. But it may also be claimed, that a larger auditorium will accommodate larger audiences and consequently will have greater box-office receipts. There is no rule for determining the happy mean between these two views. We are, however, safe in assuming that for the production of anything except grand opera and great spectacular performances, it is not well to have the auditorium too large ; and that a house containing from 1200 to 1500 seats will be more satisfactory than a larger one ; further that when its seating capacity exceeds 1800, it will have but little value as a place for rendering comedy, drama or light opera. A certain intimacy of relationship between the actor and the spectator is essential in all the lighter forms of stage production ; and the ability, not merely to hear what is said or sung, but also to follow closely the facial expressions and gestures of the actors, is a necessary condition to the enjoyment of plays of every kind, except only the purely spectacular or the purely musical, or combinations of the two. Besides, very many people hear partly with their eyes ; that is, they unconsciously follow labial movements and facial expressions as interpreters of the meaning of the sound waves which strike their ears. Therefore a large majority of the audience should be near the stage, which can hardly be the case in a theater containing more than 1500 seats, while one with as many as 1800 seats is very near the danger line.



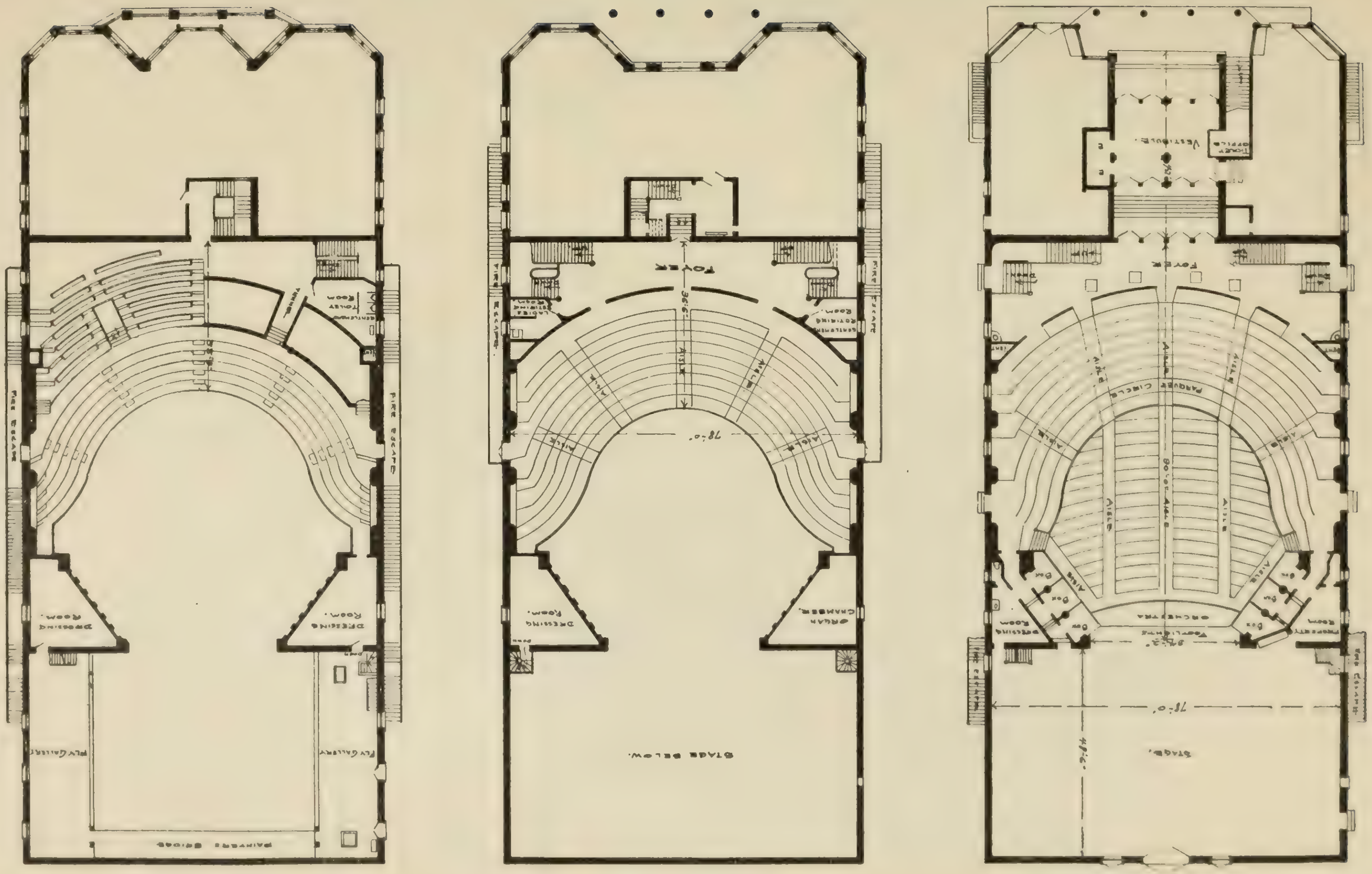
M'VICKER'S THEATER, CHICAGO.
[Longitudinal Section.]

Stage mechanism and lighting are subjects each of which would require for exhaustive treatment several articles of the length of this one. It may be said that the ingenuity and fertility of rescource displayed by the modern American stage carpenter have earned our unbounded admiration and entitle him to the deferential regard of every architect. Large stores of valuable information can be gleaned by the architect from free conversational intercourse with representative men in that craft and should be intelligently utilized in his work.

The motto of the architect designing the lighting apparatus of the stage should be in the words of the dying Goethe, "More light." No stage was ever too brilliantly lighted. But while brilliant illumination is essential, the uniform and general diffusion of light and the means for its graduation and control are of equal importance, and must be carefully studied and conscientiously designed.

It is generally difficult in American theaters to provide sufficient space for carpenter-shop, scene painters' atelier, for work-shops for the manufacture and repair of properties, costumes, etc., etc. Space is almost always considered too valuable, and these very important processes are often carried on altogether outside of the theater, or, if in the theater, in dark and inaccessible places. The intelligent architect will in all cases make an effort to give due attention to the requirements of this part of the service when he begins to plan a theater.

If good service is to be rendered by the orchestra, ample provision should be made for its seating, and there should also be a well-ventilated room available for the storage of instruments, sheet music, and the wraps of the performers.



[Plan of Main Floor]

[Plan of Balcony.]

[Plan of Second Balcony.]

M'VICKER'S THEATER, CHICAGO.

Every one within the walls of the theater wishes to see and hear what is being presented on the stage. As has been before stated, seeing is part of the act of hearing. If the seats are all so arranged and disposed, that their occupants can *see* the entire action upon the stage, it will go a long way toward enabling them to *hear* the accompanying words.

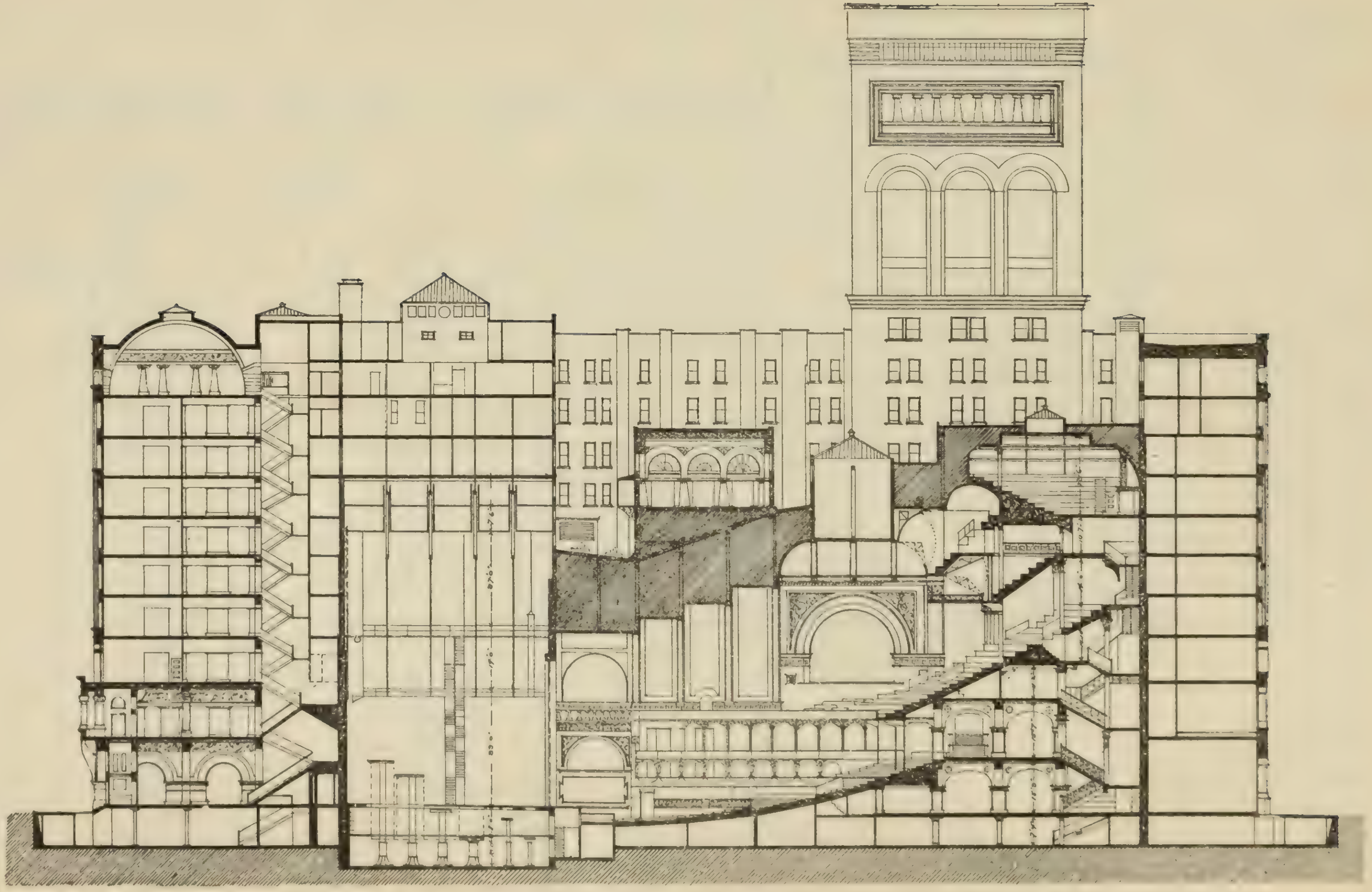
Following the principle of Scott Russell's well known isacoustic curve, but using the stage floor at or near the curtain line as the center to which the lines which determine the curve are drawn, there will result a banking of seats which gives spectators a good view of the entire stage. In working out this curve, the rise of the seats may become steeper than is compatible with fixed conditions as found in some houses. In such cases it becomes necessary to make adaptations which bring the total rise within the available limits of space. Drawing the sight lines over every second head, instead of over every head, is one of the possible modifications and as an auxiliary to this expedient for reducing the rise of the banks, as also setting the seats alternately behind each other, so that each spectator sees between and not over the heads of those immediately before him.

It is necessary in constructing the seat curve, to remember that people wish to see the sides of the stage as well as the center, and that therefore the spectator must also be given good sight lines on diagonals drawn to both front corners of the stage.

Having placed our audience in position as favorable for seeing the stage and all that is upon it as limiting circumstances and conditions allow, and remembering that lines approximating those of the isacoustic curve allow free and unobstructed progress of the sound waves from the mouths of the actors to the ears of the audience, it remains only to so construct the walls and ceilings of the auditorium that they may act as conservators and transmitters of the the sound waves originated by actors, singers, and orchestra, and to avoid the use of contours and materials which are apt to injure the quality of the sound.

The general theory of the conservation and transmission of sound waves may be stated as follows:

The sound waves, produced in the open air, travel very much as do the ripples in a pool when a stone is thrown into it, but the form of the ripples produced by the act of speaking or singing is ovoid rather than circular, the longitudinal axis of the ovoid corresponding with the direction toward which the speaker is facing. As in the case of the ripples in the pool, the sound waves grow smaller in size and in force until the sum of the friction and inertia encountered becomes equivalent to the original impulse. Therefore in the open air, unless the wind favors, the human voice in ordinary tones will

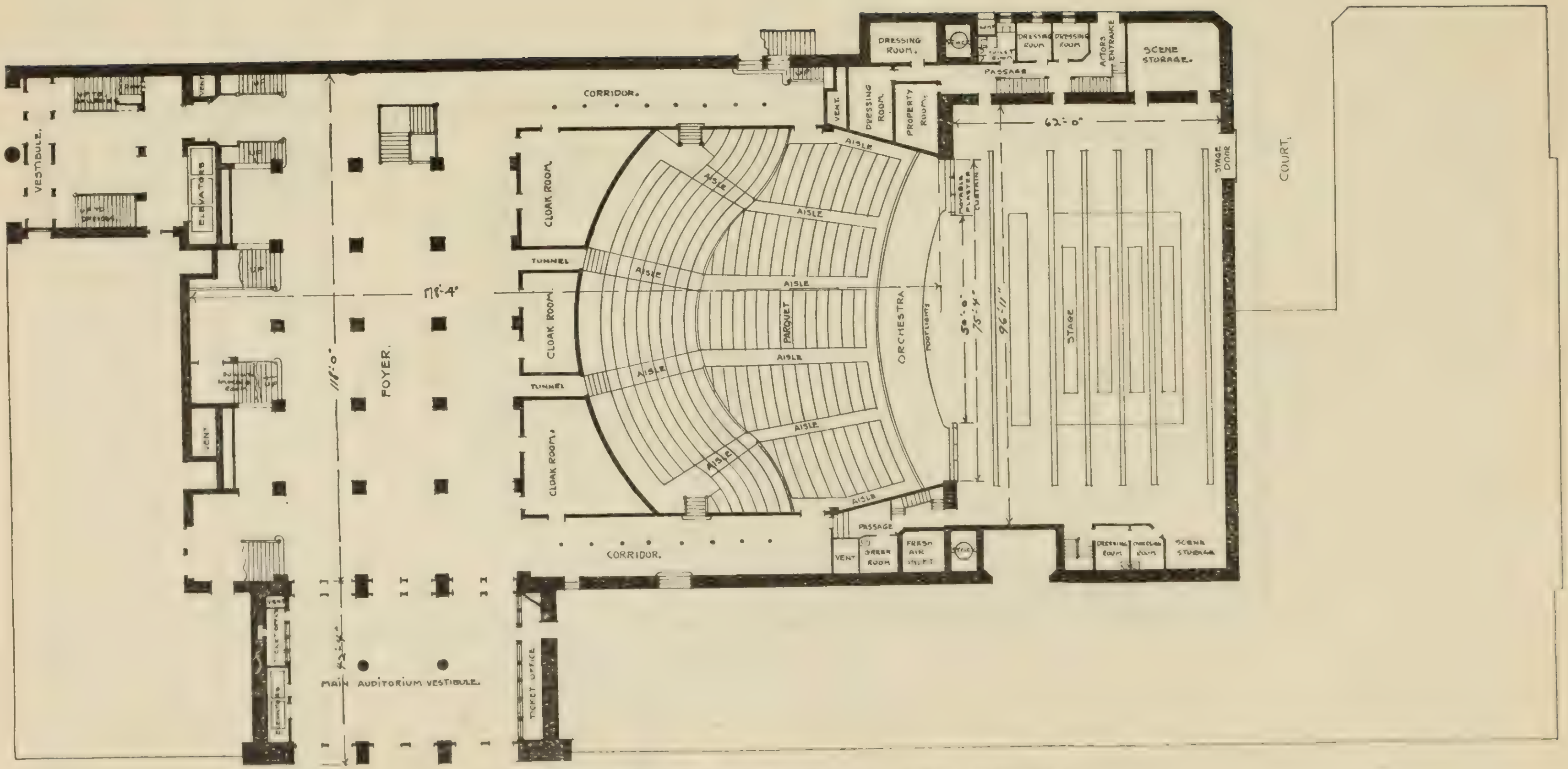


THE AUDITORIUM, CHICAGO—LONGITUDINAL SECTION.

not carry very far. On the other hand, if sounds are projected into the mouth piece of a speaking tube, the waves can travel in one direction only, and those which would in the open air travel in all other directions are forced to travel forward, and thus the original impulse in the direction of length of tube is intensified and the distance to which the sounds carry is greatly increased. A more forcible illustration of the same principle is found in the trumpet. The breath, which blown directly into the air through the puckered lips will produce but a very faint sound, audible only to a distance of but a few feet, will carry thousands of feet when projected through the trumpet. So also if the sounds produced upon the stage are, as in the trumpet or as in the speaking tube, held together at the proscenium opening, and are not permitted to diffuse themselves in any direction excepting that of the audience,—if the wall surfaces and the ceiling are so formed as to hold in the sounds, and to carry and deflect them to the ears of the audience,—then a greater number of people can hear distinctly in the same room than under any other conditions.

The practical application of this principle gives an auditorium approximately fan shaped in plan and cuts off a number of front side seats from which but an unsatisfactory view of the stage can be obtained. But the effort to conserve the sound waves influences to a still greater extent the vertical dimensions of the auditorium. The proscenium must be low, not a foot higher than is necessary to permit full view of any possible grouping at the back of the stage from the last and highest seat in the house. If the proscenium is made higher, so much more air will have to be unnecessarily set in motion, that needlessly great efforts of speakers and singers are required if their voices are to fill the house and to reach every member of the audience. The necessity for giving reasonable headroom over balconies and galleries brings with it a gradual increase in height of ceiling from the proscenium outward. This upward tendency of the ceiling lines should be modulated into a profile which deflects the sound waves downward toward the rear of the lower portion of the house.

But if the wall and ceiling surfaces, although otherwise constructed upon correct lines, are left smooth and unbroken, particularly in very large rooms or in rooms having no galleries, a certain rolling or reverberation is found to be the accompaniment of every sound produced within their walls. For by friction, and to some extent by sympathetic vibrations, the enclosing surfaces of a room affect the progress of the sound waves nearest them in such manner, that in both rhythm and velocity they differ from those which pass directly through the body of the air. These differences are cumulative, they become greater as the area of smooth and unbroken enclosing surfaces increases, and they



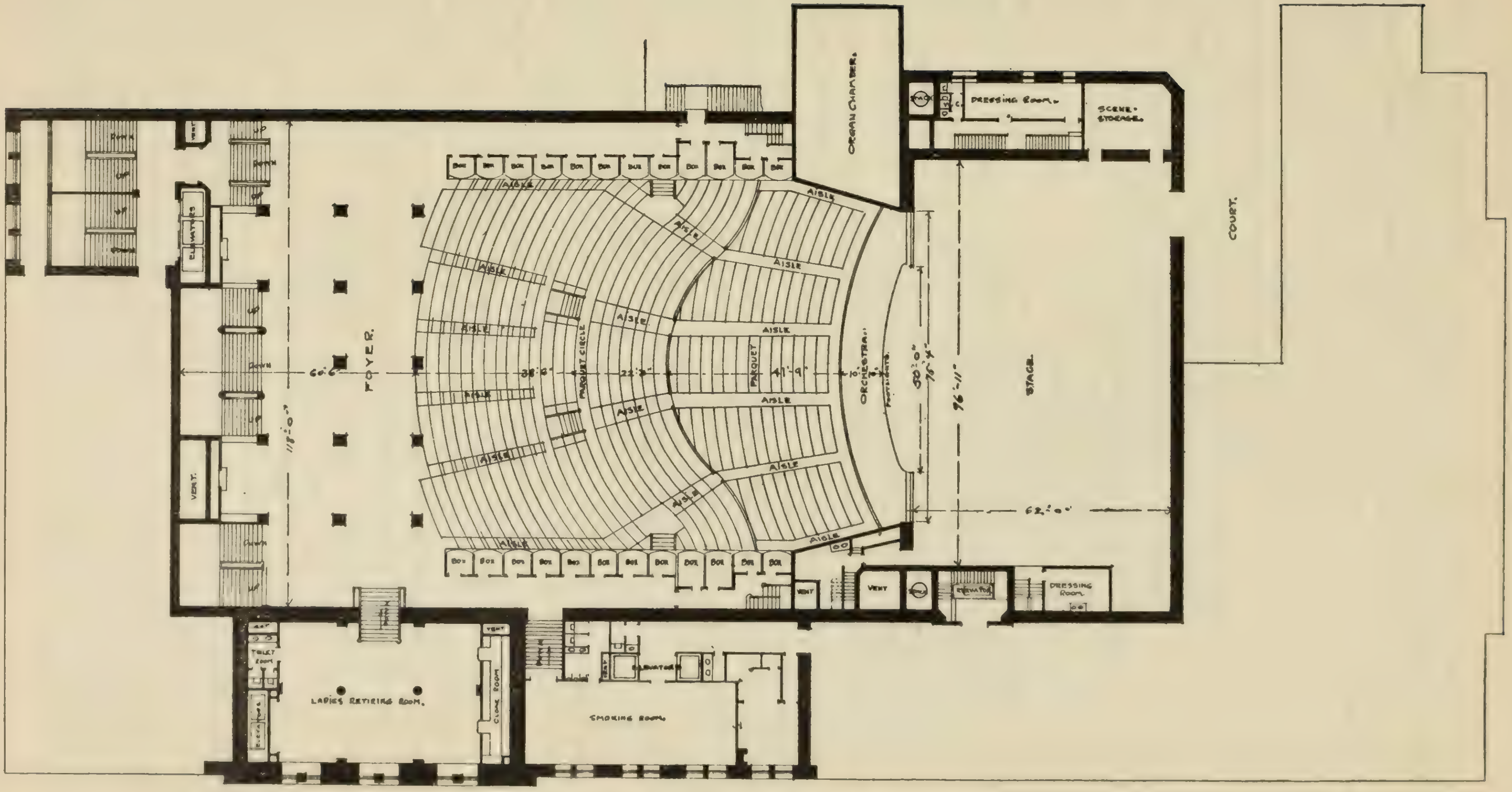
THE AUDITORIUM, CHICAGO—PLAN OF FIRST STORY.

finally assume such proportions as to cause confused murmurings and reverberations, which are in direct proportion to the extent to which a cumulative increase of variations in rhythm and speed of sound waves has been permitted to develop itself. Therefore if the enclosing surfaces of an auditorium are broken by artificial means, such as the introduction of galleries, pillars, pilasters, arches, beams, coffers, panels, etc., etc., those sound waves whose line of movement is along the wall and ceiling surfaces cannot make much progress before they meet obstructions and are deflected into the body of the house ere they have had time to attain a velocity or rhythm sufficiently at variance with that of the sound waves moving directly through the air to distress the auditory nerve. Similar means will prevent the formation of a positive echo, which indeed is only found in rooms with comparatively level floors, and with high, smooth walls unbroken by galleries.

A certain unsympathetic harshness of sound which sometimes culminates in a hard rattling reverberation is found characteristic of halls, the enclosing surfaces of which are formed of very hard and rigid materials. This difficulty is not encountered if walls and ceilings are faced with resonant materials and when these are given a certain degree of freedom for vibrating in sympathy and harmony with the sound waves. But this resonance and sympathy are apt to become troublesome in an empty or partly filled house, although they are almost always toned down in a full house. Just where to draw the line between sufficient and excessive resonance is a most difficult and perplexing problem which constitutes another reason for the practice before recommended, of not making a house much larger than is necessary for the accommodation of its average audiences.

Again, the purpose of bringing a large portion of the audience near the stage and into close proximity with the actors, is more easily attained in a wide and shallow house than in one which is narrow and long. But a house may be so broad that the number of extreme side seats from which but an imperfect view of one-half of the stage can be obtained becomes too great, thus forming a limitation to excessive lateral development of the auditorium.

An audience which would be almost lost in a theater seating 1800 or more persons, makes a very respectable showing of numbers in a house having 1500 or 1200 seats. The individual members of a moderate audience in a small house will have a sense of nearness and sociability conducive to enjoyment, while the same number of persons in a large auditorium will feel lonely, chilled, and out of place. The former will spread reports of having spent an agreeable evening at a pleasant performance, while the latter are apt to report dismal failure. It is easy to imagine the effect of such reports upon the box-office re-



THE AUDITORIUM CHICAGO—PLAN OF SECOND STORY.

ceipts. Again, people always want that which is difficult to get. Where the seating capacity of a house is very great, it is more difficult to make advance sales of season tickets, and thereby obtain a preliminary guarantee fund for the success of any particular line of performance. It happens more rarely that large houses are sold out—the stimulus of a consciousness that seats are difficult to get is wanting—all of which is in favor of a house of but moderate seating capacity.

The ideal stage is large. The stage of the Grand Opera House at Paris and of the Imperial Opera House at Vienna is each larger than any theater in America,—stage, auditorium, and lobbies included. But their magnificent proportions are but rarely called into full use. I have seen upon the stages of these opera houses renditions of such operas as "Le Prophete," "Tannhaüser," "Lohengrin," and "Flying Dutchman," in each of which there would have been opportunities for scenic displays or for processions, marches, and ballets, whose effectiveness would have been much enhanced by utilization of the great resources afforded by the enormous dimensions of the stages of these great houses. But in each case the setting was confined to a depth of stage little, if any, greater than that used for the same production in the Metropolitan or the Auditorium. I have also seen performances upon the stages of smaller European houses, such as the Municipal Opera Houses at Frankfort and at Halle, the Lessing Theater at Berlin, and have found in every instance stage settings which brought their working dimensions down to those of the stage of the ordinary American theater of the better class.

In the largest American cities long seasons of grand opera are given with an ensemble comprising a small army of people and with great splendor of scenery and costumes, requiring correspondingly large stages, of which each city where such performances are possible has one or more. There is no likelihood of so great and rapid an increase in wealth and population of these cities that the number of houses of this type will have to be increased in the near future. Grand spectacular performances are organized for the purpose of utilizing these exceptionally large stages in the intervals between seasons of grand opera. But when the great operatic companies, or the companies which have given grand spectacular displays in such houses as the Metropolitan and the Auditorium, start upon their travels, they go in light marching order; the number of principals is diminished; chorus, ballet, orchestra, are all reduced to the smallest possible dimensions; the grandeur and splendor of the scenic effects are cut down; everything is adapted to the economics of railway transportation. Shorter seasons and smaller audiences are expected in the smaller cities which they may see fit to visit, and as these visits are comparatively few in number and short in duration, there is no necessity for building in the smaller cities stages of dimensions rivaling those of the great houses of New York, Chicago, Boston, Philadelphia, and St. Louis. Again, in the larger cities almost every theater is built and maintained chiefly for a certain special line of attractions to which its stage is adapted. The great expense incident to the maintenance of very large companies and to the production of spectacular performances upon a very large scale limits their number and confines their rendition to the few large houses already in existence. So that the theaters which are likely to be built in the near future will probably be devoted to a lighter class of performance, which can be given with a smaller number of people, and with stage settings less ambitious as to size and lacking the splendor derived from magnificent dimensions. In fact, the tendency seems to be toward the organization of companies having a few members of preëminent ability, with a support as efficient as the probable financial returns of the venture may seem to permit; and this selection of individual performers of higher grade also tends to diminution of their number. In the same way, the desire for richness and sumptuousness of stage setting can be gratified more readily within a small compass than upon a stage of very large proportions. Theaters in the smaller cities are not apt to be devoted to specialties, but each must be prepared to receive upon its stage operas, spectacles, dramas, comedies, farces,—everything that is produced by the traveling companies which find it advantageous to play within their walls. The difficulty and expense of transportation are such as to curtail the personnel of even these companies, and to confine the dimensions of their scenery, etc., within the limits of a stage of moderate size.

The proscenium opening of theaters is often made so large, that it must be artificially diminished in width by the insertion of imitation draperies or of bits of set scenery, for if the stage settings were made for the full width of these excessive openings, the number of people and properties and the volume of light required would exceed the means of most companies. Probably 30 feet of proscenium opening will be found ample for all theaters less than 70 feet in width between walls, and a proscenium opening from 45 to 50 feet in width will accommodate the most elaborate spectacles ever presented in this country. The proscenium openings of the Auditorium, of the Metropolitan, of the Academies in New York and Philadelphia, and that of the Boston Theater are near these figures. It is therefore not at all likely, that a proscenium opening of more than 40 feet will be required for any theater other than the preëminently large ones before enumerated.

In the matter of depth of stage, it would seem that it is almost impossible to give effective rendering even to parlor comedy on a stage of less depth than 25 feet, and that 40 or even 50 feet would not be an excessive depth, or one involving uneconomic results for a theater devoted to miscellaneous performances. With reference to this matter it must be borne in mind that, for the purposes of any performance, it is much easier to cut off part of the depth of the stage by means of suitable drops, than it is to add to its depth if the stage is built too shallow in the first place, and it will always be safe, in designing a theater, to take for increase of depth of stage all the space not absolutely necessary for other purposes.

In the same way it is very desirable to have as much space as possible on each side of the proscenium opening. In the absence of large assembly rooms for actors, for chorus, ballets, supers, etc., that part of the stage which is invisible to the audience can very conveniently be used for forming processions, marches, etc., and for so assembling the various people engaged in a performance as to enable them to appear promptly upon the scene. Part of this space may also be utilized for the storage of scenery, of properties, and of the baggage of traveling companies.

The height of the stage is another dimension which can hardly be made too great. Sixty or 70 feet from the stage floor to the rigging loft is not at all excessive, and 80 or 90 feet or more has been used to very good advantage. It is very desirable that it should be possible to lift the largest drops bodily without folding or rolling, and this can only be accomplished when there is abundant height.

In the design of an American theater the facilities for handling the baggage of traveling companies must not be overlooked. The quantity of baggage, consisting of scenery, properties, costumes, musical instruments, etc., carried by many traveling companies is quite astonishing to the uninitiated. It frequently happens that all this must be taken into the house late of an afternoon, prepared for a play in the evening, and removed and packed ready for an early train on the morning following the last performance.

The matter of dressing-rooms is one which well merits attention and study. It should be remembered that the more comfortable the artists who are to appear upon the stage can be made in the dressing-rooms, and the more direct and commodious the means of communication between dressing-rooms and stage, the better will be their condition for pleasing the audience.

ELECTRICITY

Conducted by Franklin L. Pope.

IT has been a matter of much regret among electrical engineers that the manufacturing company which constructed and operated the Intramural electric railway at the World's Fair, last year, has not seen fit to make public a detailed account of the results of its operation. Of course the right of the company to reserve the information thus gained for its own benefit, instead of sharing it with the public and with its business competitors, cannot be questioned, and we do not wish to be understood as criticising its action in the matter. But in spite of the official reticence as to the facts and figures of the working of the Intramural, some information of value has transpired from time to time. In a discussion in the Western Railway Club respecting the present utility of electric motors on railroads, Mr. Baker, who had general charge of the Intramural road during the fair, said that the motor-cars used enabled the work to be done with a weight on the track of only about 80 per cent. of that which would have been necessary with independent locomotives, whether electrical or steam. He observed that four motors made a very economical arrangement, because, with all the motors in series, at one-fourth the normal speed, the motors are working at maximum efficiency within a few seconds after starting. The average speed attained was about ten miles per hour, but would have been much higher but for the excessive curvature of the line. With a straight track this speed might easily have been doubled. The average number of passengers carried was a little over 33 per train-mile, though in October it averaged over 50. The average on the Manhattan system in New York is about 24 per train-mile. The total expense of fuel during the month of August was 4.3 cents per train-mile. Four cars were ordinarily run in each train, one of these being the motor-car. The latter weighed about 26,000 pounds, which, with 20,000 pounds for the motor and attachments, and 14,000 pounds of passengers, made about 60,000 pounds, giving substantially the same traction as a 30-ton locomotive.

In the course of the discussion referred to, it was pointed out that the cost of fuel on the Intramural road, as given by Mr. Baker, was about 4 cents per train-mile on a 50-ton or 60-ton train, while on a steam-railroad the same expenditure of fuel would haul a 500-ton freight-train at the same speed, indicating that modern locomotives are doing about eight times as much work as the electric locomotive with the same fuel. It was stated by an expert present that a horse-power-hour can be generated in a modern locomotive by the evaporation of from 25 to 28 pounds of water, and that in average service from 5 1/2 to 6 pounds of water could be evaporated for each pound of coal. One member remarked that the figures presented at the National Electric Light Convention, showing the average amount of power generated at the principal electric-light and -power stations of the country in proportion to the amount of coal consumed, were so low that he would be ashamed to acknowledge them as an average for locomotive performance. The performance of the Metropolitan electric railway of Chicago, which is to go into operation this fall with electric motors, may be expected to show much better results than it was possible to attain under the conditions with which the Intramural line was necessarily handicapped. It does not appear, as yet, to have been demonstrated that in this class of service electricity is any more economical of fuel than steam when directly used.

THE *Electrical World* publishes an interesting and well-illustrated account of the new electric street-railway recently put in operation in Zurich, Switzerland, which seems to combine many of the best features of both American and European practice. On account of the high price of coal in that country, everything has been planned to secure the highest economy in operating expenses, but this has been done by intelligent and skilful engineering, and not by the makeshift methods with which we in America are only too familiar. The track is 4.6 kilometers (about two miles) in length, and is a constant ascent from the landing on the lake shore to the other end, where a spacious one-story stone building serves for both a power-house and a car-barn. The gage is 1 meter, and the maximum grade 6.3 per cent. for 115 meters. There are two compound-wound generators of the four-pole iron-clad type, each of a capacity of 66 kilowatts, which run at 450 revolutions per minute. Only one of these is run at a time, the other being held in reserve. Each generator is driven by a compound condensing vertical engine, running at 240 revolutions and belted to it as in American plants. There is also an auxiliary engine of 45 indicated horse-power coupled direct to an auxiliary four-pole generator. The most interesting feature of this plant is that the current for operating the cars is derived both from the generator and from a set of storage-batteries coupled in parallel. There are 300 storage-cells of the Tudor type, installed under a ten-years' contract, by which the manufacturers are held entirely responsible for their maintenance and operation. The battery proper comprises only 240 cells, the remaining 60 being used for regulating purposes, and being put in or out of connection as required, by an automatic switch mechanism. The normal capacity of each cell is 245 ampere-hours at 80 amperes discharge, though 160 amperes can be taken momentarily without damage. The aggregate battery is rated at 120 amperes and 550 volts, and is calculated to run nine cars from 1½ to 2 hours, independently of the generators. The auxiliary or regulating cells are charged by the auxiliary generator, usually at the time of lightest load. With the nine cars in ordinary use, the average current output is 90 amperes, although momentary fluctuations vary this from 0 to as high as 200 amperes. The storage-battery serves to take, as it were, the peak of the load, by which a notable economy is effected in the dimensions and first cost of the steam-equipment and generators, these being of but little more than half the capacity that would be required under the ordinary system. The cars, trolleys, and overhead construction are of the familiar American type, and some of the switches and other fixtures are of American manufacture. The line has been in successful operation since March 1, and has done a large and profitable business from the beginning. We shall watch carefully for a statement of the cost of operation of this road, which doubtless will be given to the public in due time.

THE *Electrician* (London) gives an analysis of the capital and revenue accounts of the different electric-lighting companies operating in the British metropolis, from which some interesting results may be deduced. The figures are given on the basis of the 8-candle-power lamp as a unit. The average capital investment per lamp connected is $25, the best individual figure reached being about half that amount; the aggregate gross earnings for 1893 were $1,325,000, and the aggregate kilowatt-hours registered by the house-meters was nearly 10,000,000, an increase over the preceding year of about 25 per cent. The average market price per kilowatt-hour in London last year was 12.76 cents; the average earnings of each lamp connected was about $1.85; and the average cost of coal per kilowatt-hour sold was 2.65 cents, being a reduction of something like 10 per cent. over the previous year. The lowest coal-bill per kilowatt-hour was that of the Kensington company and was 1.48 cents. The *Electrical World* makes some computations based on the returns of the Massachusetts electrical companies to the state commissioners, from which it appears that the average investment of capital per kilowatt capacity of the ten largest stations in that state is $573, which certainly is a very high figure. The operating expenses in the same stations appear to average about 60 per cent. of the gross income. The average receipts per horse power-hour cannot be exactly determined, but may be reasonably estimated from the returns as given to be about 12 cents per horse-power-hour. This, as will be seen, is considerably more than the London figure.

A RECENT lecture by Professor H. J. Ryan, of Cornell University, gives some points of interest in reference to the construction and equipment of a modern power-station. The amount of floor-space required per horse-power varies from 9.5 square feet for plants of 2000 horse-power and upwards, to 22 square feet for plants of 100 horse-power and under. A fire-proof building of brick and iron may be estimated to cost about $40 per horse-power for 100-horse-power plants, which, for plants of 2000 horse-power and over, falls to $17 per horse-power. The best type of engine for railway power-stations is the compound condensing engine, and the engine capacity should be from 20 to 25 horse-power per car operated. The actual amount required varies from 15 to 18 horse-power per car, sometimes rising to 20 on steep grades. The estimated cost of steam plant is from $45 to $55 per horse-power for high-speed, and $65 to $75 per horse-power for slow-speed engines of the Corliss type. A power-station generator must be absolutely automatic, in practice as well as theory. Machines that do not give an increase of pressure proportionate to load work badly when coupled together. The cost of the electric-generating system, including switchboards, should be from $35 to $40 per horse-power. The switchboard must be mounted on an incombustible base, and a rheostat, voltmeter, and dead-beat ammeter provided for each generator. A trustworthy form of lightning-arrester and a safety circuit-breaker which will act promptly at the point at which it is set, are absolutely essential. Fuses are less reliable than magnetic devices for this work. An essential feature of the switchboard should be an equalizing bar which places the series coils of all the machines in parallel with each other, and thereby prevents the possibility of any generator acting as a motor in case its potential accidentally falls too low, a circumstance liable to result in serious injury to the machine.

PROFESSOR KENNEDY, who has been studying the returns of the electric-lighting stations of Great Britain, states that the cost of coal appears to average not far from four-tenths of the total working expenses of a station. As to the loss in transmission, he mentions that in one low-pressure system, laid out for a loss of 20 per cent. in the feeders, the actual average loss during one year amounted to only 10 per cent., while in the mains and transformers of a high-pressure alternating system, they are usually not less than 25 per cent. of the energy generated; a loss which he thinks might be materially reduced if a less number of transformers of larger capacity were more generally employed.

THE following interesting comparison of the mechanical and electrical methods of transmitting power was given by Mr. L. B. Stillwell at a meeting of railway-men: A steel cable 1½ inches in diameter, traveling at the rate of twelve miles per hour, can transmit nearly 2000 horse-power. But by taking a copper wire, 1 square inch in section and applying to it a potential equal to that which is in use to-day in at least one place in this country,—viz.: 10,000 volts, at 1000 amperes per square inch,—we find we are transmitting in an invisible form over that wire more than 13,000 horse-power, which is enough to rupture instantly six such cables as are ordinarily used in operating a cable railway. As much power can be transmitted through such a copper wire under the conditions named as through six such belts as were seen at the World's Fair, six feet wide and running at the rate of a mile per minute.

THERE has been a good deal of discussion, first and last, in respect to the reason for what is undoubtedly a fact, that the storage-battery has been on the whole commercially successful in Europe, while in the United States it has been, with perhaps rare exceptions, a commercial failure. Mr. W. W. Griscom, in a paper read before the American Institute of Electrical Engineers, gives what we have no doubt is the true explanation of the puzzle. It simply is that in this country storage-batteries are worked with too small a margin of safety. The fault of this state of affairs seems to rest entirely with the manufacturers. As Mr. Griscom pointedly observes: "A storage-battery continually worked to its commercial rating is a commercial failure. A storage-battery worked sufficiently within its capacity is invariably a commercial success." This, being interpreted, means that the manufacturers of storage-batteries, like those of arc-lamps, are accustomed to sell them under a so-called "nominal" rating, which is intentionally fraudulent and misleading. If we buy a steam-engine of 100 horse-power we expect to get one which can be worked continuously, day in and day out, at 100 horse-power, without danger or injury to the machine. If we buy an arc-lamp of 2000 "nominal" candle-power, we may expect to get, according to Professor Anthony, about 500 actual candle-power. The discount on "nominal" storage-battery capacity, according to Mr. Griscom, is not quite so great as this, it being only necessary to add 50 per cent. to the commercial rating as a practical factor of safety. This, it appears, is what is done in Europe, and is all that needs to be done here. Mr. Griscom deserves the thanks of the profession for his simple and obvious solution of a very troublesome problem.

THE advantages of the long-distance telephone as a branch of the military service have been strikingly exemplified during the recent industrial disturbances at Chicago. The president and his cabinet at Washington were in almost continuous session for several days, and, by means of the telephone, were placed in direct and instantaneous communication with the representatives of the government at the front. Not only is there a great saving of time when the telephone is thus used, but the possibility of misunderstanding and mistake are reduced to a minimum. The vigor and promptitude with which this crisis was met by the officers of the government was in no small measure rendered possible by the opportune aid afforded by this great modern invention.

THE Oerliken Machine Works of Switzerland have long been recognized as one of the foremost establishments in the world in the development of modern methods of transmission of power by electricity. One of the finest examples extant of the technical skill and knowledge of its staff of electrical engineers is its own transmission and distribution plant, which is described by Frederick Bathurst in a recent number of the *Electrical World*. The power-house is situated on the little river Glatt, at a distance of about fifteen miles as the line runs, from the Oerliken works. The building is of brick, and is equipped with three horizontal turbines, each of which carries upon its upright shaft a separately excited generator having 32-pole field-magnets, which revolve within stationary armatures of ring form. There are three generators and three transformers, two of each being employed in ordinary work, while the third is held in reserve. The machines run at 180 revolutions per minute, and generate a three-phase alternating current of 85 volts potential, at a frequency of 48. This current is raised to 13,000 volts by transformers immersed in oil, which is cooled by being made to circulate through pipes coiled in a cold-water tank. The line carries four bare copper wires of No. 8 B. & S. gage, upon double-shed porcelain insulators, three of the wires being ordinarily used, and the fourth held in reserve in case of accident. Every fourth pole has a ground-plate and lightning-rod. Two telephone wires are run underneath the power wires, a plan which has proved by experience to be much safer than placing them above as was formerly the practice. The amount of power transmitted is approximately 340 kilowatts and the line loss does not exceed 2½ per cent. Arriving at the factory, the current is again transformed, being lowered to a potential of 190 volts for general service. There are 40 motors in use in different departments of the works, varying in capacity from 3 to 80 horse-power and running at speeds of from 2000 to 500 revolutions per minute. The smaller motors are supported as a rule upon brackets inserted into the wall, thus economizing valuable floor-space. The wiring and starting arrangements are remarkable for their simplicity, nothing more being required than a three-pole switch fitted with safety-fuses. A 6 horse-power motor will start from rest, either with or without load, and attain full speed within 20 or 30 seconds. In some instances, special starting appliances are found necessary or convenient, especially in the case of the larger motors. Any motor in the establishment will carry a temporary overload of 50 per cent. without injury. One of the most interesting applications of the motors is in the case of the 10-ton shop-cranes, each of which is fitted with three motors; two of 3-horse-power capacity for traversing, and the cross-travel of the trolley-carriage respectively, and the third of 9-horse-power capacity for hoisting. The movements of the first two motors are controlled by a simple double-headed three-pole switch, while the 9-horse-power motor has a simple iron resistance-box with six contacts. Altogether the Oerliken factory furnishes one of the most complete and interesting installations of electrical power-transmission and distribution in the world.

A LARGE and increasing business is being done in the manufacture and installation of small self-contained direct-current plants for isolated lighting. A very compact apparatus of this kind has just been supplied by the General Electric Co. to the new Manhattan Life Insurance building in New York. The generator is of the six-pole ironclad type, giving 25 kilowatts at 300 revolutions, and is coupled direct to the shaft of a vertical 9½′ × 10′ engine, rated at 40 horse-power which is mounted on the same base. Such a combination plant occupies but very little space, and is stated to have given excellent satisfaction.

IT has long been known, or, at all events, strongly suspected, that the quantity of light emitted by an electric arc-lamp, other things being equal, was largely dependent upon the quality of the electrodes used. It is said to be not an uncommon occurrence to come across particular carbons which show a difference of 50 per cent. in the amount of light produced. Professor W. A. Anthony, who has made many hundred photometric measurements, has stated that a 450-watt arc (nominally 2000 candle-power) in a clear glass globe does not ordinarily give more than 500 candle-power in mean spherical measurement. Recent experiments in Germany have given a much better result, 1292 candle-power having been obtained with a lamp of similar capacity. This great difference can apparently only be accounted for by differences in the quality of the carbons, and hence would seem to be a matter that urgently needs further and more careful investigation. It appears to be generally admitted that the carbons made in Germany and Austria are as a rule far superior to those produced in this country.

THE large power-house of the Brooklyn City Railroad Co. is so located that all the coal used has to be transported 1000 feet from the wharf to the boilers. By means of machinery devised and erected by the C. W. Hunt Co., it has been found possible to take coal out of the hold of the vessel and deliver it to the boilers at a cost of three cents per ton.

ARCHITECTURE

Conducted by Barr Ferree.

THE publication of architectural articles in the popular magazines is generally supposed to be a healthy indication of a growing and widening taste in architectural knowledge among the non-architectural public. It may be seriously questioned if it is any such thing. Editors are human folk, like the rest of us. They aim to make their periodicals as good as they can. Striving to know everything, they really know very little, and hence are quite unable to bring a specialist's knowledge to their task. There is probably no subject on which they are more readily deluded than on architecture. Architecture in America is so very bad in general, and it is so very easy for wordy persons to write most delightfully and critically upon it, that the very worst things may pass current as the wisest. Architectural criticism, as it is generally practised, comes dangerously near to jugglery with words. Given a few ideas, or semblance of ideas, a smattering knowledge of architecture, which need not be much more than familiarity with shapes and sizes of doors, windows, and other elementary details, and a large vocabulary, and your architectural critic can go blithely forth into the world, seeking reputations which he may make and destroy, looking around for men he may uplift, for others that he may cast down, and at the same time gather in the few dollars that make his attempts profitable to him as they are apparently enjoyable. It is impossible to estimate the evil such a person can do. If he can gain ready entrance to the big magazines, a circumstance that is by no means always due to individual merit either in the writer or in his work, he can in a reasonably short time acquire a vast reputation. People who know nothing of architecture,—and of these there is a vast herd,—look up to him as a huge fountain of light. Architects and practitioners eagerly scan his efforts for praise or condemnation, and their estimate of his ability as a critic is usually based upon his own personal predilection for their work. If he thinks it fine he is a fine critic; if he condemns it the word *condemn* is a very faint way of expressing the opinions they pour forth. That is the great secret of architectural criticism, though, like many great secrets, it is of no special value to the world at large. For the manners and works of architects are as varied as the hues of sunset, and no critic, be his vocabulary as great as the Century Dictionary's itself, can please all. Some must suffer that some be pleased.

SEE the architectural critic sallying forth conquering and to conquer! Armed with no larger weapon than a pen he accomplishes prodigies of valor beside which the combative attempts of the late Don Quixote, of blessed memory, are as babe's play. Mounted upon his favorite hobby-horse he sweeps over the world brushing down all he can and vainly trying to demolish those who persistently prosper, with the utmost bad grace in the world, notwithstanding his efforts to drive them out of business. His armor is nothing more than sets of the latest dictionaries, and with these he rides unscathed through the bitterest battles. From his own standpoint it is a fine sight and fine sport. To those he loves he deals out praise unstinting; to those he hates he administers his severest cuts with the most charming smile and in the very best language at his command. Gayly and wildly he rides, rocking his hobby-horse up and down with a vigor that would make a ten-year-old child die of envy. He bellows loud and long, that all people may bear witness to his prowess and to the puniness, not to say insignificance, of his opponents. These poor people have nothing to say. If they are sensitive folk they suffer unheard and in secret. If they are case-hardened and dictionary-proof they go calmly on gathering in clients, gaining important pieces of work, and waxing rich, regardless of the bellowings that are intended to efface them from off the earth. The net result, in this last case, is very much like pouring oil upon a fire. The critic will never be downed and he rarely changes his opinion. To do so would indicate a lack of confidence in himself and lower him in the estimation of those people who look upon his ravings with the same interest they are apt to regard "real crawly" cheese after dinner. It is a one-sided contest in which the advantage is very apt to lie with the man who stirs it up. For the man who talks the most often has the advantage over the man who thinks the most, and thinking is a process that the architectural critic can often get along very well without. Of course he does not know this. He regards his effusions as the profoundest essence of thought, and would probably be much surprised if he were told they were not. They can be, it is true, but as it is possible for architects to achieve the highest of architectural successes without any violent thinking exercise, it is quite natural that the critic should follow the same course. School-boys engaged in arguing that much-threshed-out problem, "Is the pen mightier than the sword?" would do well to illustrate their remarks by the performances of the architectural critic.

THE word "Frenchite" is not to be found in any of the dictionaries, and the reason thereof is very clear, since it was first used—and not long ago—in these pages. It is formed from the word "French," the English word applied to the nation and people and things, products, wares, ideas, of and from France. It is therefore one of the most glorious words in the English tongue, recalling and designating as it does one of the very finest countries and people in the world. The word "French" implies nothing that is not honorable; it recalls many momentous events in history; it describes many wonderful and extraordinarily-interesting objects of art; it stands for many pronounced, advanced, and healthy ideas. It is a great word and a good one. It is a very fine word. The suffix "ite" is Greek. The word "Frenchite," therefore, is a somewhat barbarous combination of English and Greek, but no worse than other combinations of a similar kind that are being put forth by most eminent authority every day. The use of the suffix in the present word is the primary one of signifying "a disciple, adherent, or follower of a person, a doctrine, a class, an order, etc." Using the word exclusively to designate the adherents of certain architectural ideas and forms, it has a definite and legitimate meaning. Like the word "French" it is a good word and an honorable one. The true Frenchite should glory in that title as his most valued possession. The characteristic quality of the architectural Frenchite—and we are concerned with no other—is adherence to forms and vehemence and persistency with which certain fundamental elements are accepted, practised, and taught as the fundamentals of architecture in all things, under all circumstances, and in every condition. We are sorry to learn that many Frenchites object to being so designated. Fie upon such men! The word is not a mark of shame, but of glory. It is a word the people can understand, since the "French" portion of it is clear and to the point. It is descriptive as well as expressive. The word "Écolist" may be more elegant, but it is not so picturesquely and directly descriptive. As a new word it has a certain element of strangeness attached to it. But it is a noble word, expressing noble ideas, and referring to noble men. For our own part we should be proud and glad were we able to describe ourselves with this word; but, though more French than most Frenchites in America, we cannot so call ourselves. We trust we can depend on the sympathy of the Frenchites in this our great misfortune.

THE world does move, even in Boston, for the *Architectural Review* has a new editor whose views and sympathies are very considerably opposed to those that have heretofore dominated that very interesting periodical. The world of architectural students owes a debt of lasting gratitude to Mr. C. Howard Walker, who has lately relinquished the editorship of that publication. Though not its editor from its beginning, Mr. Walker has always been in active sympathy with it, and when it was transformed from a students' organ of the Massachusetts Institute of Technology into a full-fledged, independent architectural journal he naturally became its editor. Its success has been largely due to his industry, sagacity, and judgment, and even those who, like ourselves, differ with him on architectural fundamentals, must regret that we are no longer to have the benefit of his cultured judgment on architectural matters or profit by the ability with which he conducted his periodical. And we do not hesitate to say so, though he has pursued this Department with a venom and vigor that entitles his criticism to rank among the most vituperative of the day. Mr. Robert D. Andrews, who succeeds him, represents a very different school. Mr. Walker is a Beaux-Arts man of the Beaux-Arts, though never himself a student in Paris. Mr. Andrews stands for a broader school of architectural training, and will bring different sympathies to his work. Many interesting changes may be looked for in the *Review* under his management, and its proprietors are to be congratulated on securing so capable and competent a man to conduct it. The *Architectural Review* is the only architectural periodical in America that boasts a practising architect as its editor. This privilege it enjoyed under Mr. Walker and this it will continue to enjoy under Mr. Andrews. There can be little doubt that to this circumstance the *Review* owes the greatest measure of its success. It has been distinctly an architectural journal of architects, for architects, by architects. Architectural journalism in this country has unquestionably suffered from the fact that its journals are not conducted by architects. It may not be necessary to be an architect to be a successful architectural editor, but the history of the *Review* shows what very effective work can be accomplished when this is the case. Mr. Andrews assumes charge of a highly-successful, well-established journal. The preliminary work of placing it upon a firm foundation has already been accomplished. With the new ideas he must necessarily introduce, with the enlarged sympathies he brings to his new task, its scope and success in the future must be greater than in the past. We are glad to welcome him among the architectural editors and felicitate the profession upon the advantages that must accrue to it from his new field of labor.

An editorial in *Architecture and Building*, some time ago, directed attention to the number of architectural societies in New York, and incidentally pointed out the connection between their growth and the interest in architecture as an art. Some five or six societies were enumerated. The oldest is the New York chapter of the American Institute of Architects, whose value is perhaps not so great to the profession or the public as it should be, but which nevertheless has an importance that cannot be overlooked. The Architectural League, which, under the late long presidency of Mr. Russell Sturgis, acquired an unusual influence, is a much more active organization and, more than the chapter, is the hope of the profession in New York. Its field of work is large and important, and naturally increases from year to year. This, with the Department of Architecture of the Brooklyn Institute of Arts and Sciences, in Brooklyn, brings the list of strictly architectural societies in New York to an end. But allied with them are the artistic societies like the Metropolitan Art Society and the Sculpture Society. Both of these, while occupying somewhat similar ground, are entirely distinct in idea. The Metropolitan Art Society is an organization intended to take up all questions of art affecting the city of New York at large, but more especially in the way of providing opportunities for the carrying out of public works of art. Its first effort has been a competition among painters for the decoration of a court-room in the new county court-house. This proposal should receive the hearty support of every thoughtful citizen of New York, since the building in question is not only the latest addition to the civic structures of that city, but is also one of the worst. Its exterior being as devoid of artistic interest as is possible in a building, it is a work of positive philanthropy for the Municipal Art Society to seek to give it some artistic interest by decorating one of its rooms. The Sculpture Society is more professional in its aims. It not only takes up the question of sculpture as applied to architecture, but includes conferences among sculptors on professional topics, which are not only of the widest interest to the public but are likely to be of the greatest value to its professional members. The organization of two societies such as these within a single year is ample evidence of the general interest felt in art and its relation to architecture. The governing body in both is composed of painters, sculptors, architects, and laymen, representing all phases of art, and thus having a strength impossible among separated interests. Membership in both societies is open to all interested in the subjects with which they are concerned.

In no profession does professional feeling amount to so little as in architecture. Medicine stands almost at the other extreme, for there professional feeling is so strong and pronounced as to be sometimes popularly supposed to be a menace to public safety. Doubtless this is an exaggeration, but a fraction of the professional feeling of the doctors could be profitably spared to the architects, to the lasting profit of both. Architecture in modern times has become a personal art in which individuality, so far as it goes, takes the place of schools. The concerted action that produced the marvelous monuments of the middle ages has long since been swept away. Instead of men working in the same line we have men working in individual lines, without the smallest reference to what their brothers are doing. This isolation is felt in more ways than in the development of myriad styles of architecture. It affects unity of work in every direction. There is no "trade" feeling, no unity of thought or of action that is often so powerfully operated in other professions, and even in the trades. The bricklayers, to take an extreme instance, have more unity of feeling than the architects. It is not a very highly-developed feeling, it is true, but it amounts to a great deal from the bricklayer standpoint. The architect can show nothing corresponding to this. If he would raise the standard of his profession by excluding from it all save men of a certain standard of ability, he does not begin by rendering it impossible for those who do not come up to his ideal from obtaining business in a professional way, but carries a bill for licensing architects to his legislature, that the standard of art be fixed by law. If, after years of effort, the architects get a bill through congress permitting a high government official to throw open certain work to them at his discretion, they get muffed if that discretion is used in a way that they think it ought not to be used. This last is not, perhaps, a good instance to quote, since if there ever was a subject on which architects in general were united it was that government architecture should be in the hands of private practitioners, so far as designing and superintendence are concerned. There are many professional questions that should naturally come before architects for professional discussion. The Architectural League is the only body in New York that takes this responsibility upon itself, and even here a good deal of the talk is by those who are not architects. The Society of Beaux-Arts Architects, New York, has, however, a professional standard that it seeks to maintain. Among strictly professional bodies in America it alone has this peculiarity. However one may differ with it in its uses, function, utility and worth, it is impossible to deny that in this, at least, it has struck a note that other branches of the profession would do well to follow.

The New Orleans *Picayune*, in some remarks on a recent magazine article on high buildings, said that it was impossible to believe that any one could take an interest in such architecture. The comment contains more truth than the newspaper evidently supposed. It is not true that it is impossible to believe that people could be interested in high-building architecture, but it is true that very many people are not interested in it, and until all who may have occasion to build high buildings, to own them, to transact business in them, to pass before them, to have anything to do with them in any way—until all these are interested in them they will very likely be intensely stupid and dull structures. Very many of them are that and nothing else, and, if it were not that a few men have been wise enough to apply artistic methods to their design and have given the world some interesting buildings, there would be nothing but condemnation for them individually and as a whole. But lack of interest is not limited to high buildings. There is a general indifference to architecture in all its phases even in the most enlightened quarters. This is partly due to the architects, who do not always do the best they can, but more especially to the general public that is quite oblivious of the meaning of architecture. If it goes to architectural exhibitions it finds gaylycolored walls that would put a picture collection to shame for sobriety. If they go to architects they are personally acquainted with, they get that man's own style, which they may not like but which is accepted because they think its designer knows what they want better than they do themselves. There is serious need of interest in high buildings. These costly structures are built to last a long time. They will not speedily be replaced and may be considered permanent. This makes it all the more necessary that they should be designed with the very highest artistic skill. We may, perhaps, not be unduly concerned as to what posterity may think of our work, but for our own sake, to put the question on its proper ground, it is becoming that our largest structures should be possessed of that artistic quality that can only come from general interest in them. It must be reckoned among the anomalies of architecture that men who would not put a hundred dollars into a thing they were not interested in or cared nothing about, will not hesitate to spend a million on a building that may be utterly deficient in architectural merit. They are not properly interested in it. Architects would do themselves a world of good if they would remedy this evil.

An architect who has succeeded in giving a squat effect to a thirteen-story building has achieved such a success as few can boast of. This is just what the architect of the Postal Telegraph building in New York has accomplished, and he has done it with the simplest means in the world. His design is simple, and, save for an impossible flat archway reaching through three stories and forming the entrance of the building, embraces no especially incongruous feature. The upper stories are sufficiently plain for a commercial building, though the main front has somewhat the effect of not having quite enough windows in it. Light interiors are the first essentials of a modern office-building; but this front seems to have somewhat more wall than is needed. The building starts with a basement in three stories, plainly treated, save for the ugly flat arch just mentioned. Over this comes a mezzanine story, quite unnecessarily thrust in between the base and the superstructure. This last is seven stories high, and here the architect began to get in the fine work that ended in the squattiness of his design. With that strange fascination for the horizontal that amounts almost to a mania with New York architects, he has omitted any expression of the vertical. But in order that his façade be not wholly without some lines of accentuation, he has run a Greek fret across each story, directly under the window sills, where it cannot even express the floor-lines but is simply a meaningless unnecessary way of slicing up the building. The great feature of this design is contained in the story immediately over the superstructure, which is the eleventh from the ground. This floor is to be occupied by the telegraph company, and that, perhaps, is the reason why it has been made higher than the others. At all events, the practical results are most distressful, since the elongation of this story, together with the manner in which the building has been cut up into slices by the horizontal lines running across it, produce a compressed effect that may be colloquially described as "squat." The upper portion of the building is exceedingly badly managed. The cornice, which is of copper, is supported by eliptical arches of that material, with an effect that is most unhappy. But the design is not to be condemned offhand. It is not obtrusive, nor does it neglect the commercial requirements of a commercial building. The meaning of the problem has not been fully grasped, nor has the architect been entirely alive as to what he ought to do. Entire success could not have been had in the lines followed.

During idle moments architects are prone to consider, for lack of other things to do, the ways and means of advancing themselves professionally and financially. The latter is the more important phase to be considered, and is exactly what any business man would do. There is no reason at all why an architect should not have the privilege of consulting his own advantages. Of course no one will dispute that, but some difference of opinion can rightly enough exist as to ways and means. The licensing of architects is one of these questions that come up when there is nothing at all to think about, and that go down without any one being able to explain why nothing was done. The principle of licensing architects is simply to obtain from the state authority an ability that architects, as a class, are too indifferent to obtain through their own personal exertions. It is an admission,—though perhaps no architect would care to make it public,—that they are not really as important or necessary body of men as they would like people to imagine them to be; they need a legislative act to give dignity to their importance. Doubtless this topic will come up for years to come, and will continue to do so until it has been put into practical operation. If any state will pass a law requiring architects now engaged in the practice of their profession to pass an examination for a license we should think it would do a great deal of good. It might be difficult to get a board of examiners who would know enough to examine; it might be more difficult to set up a standard whereby all architects shall be measured, just as we measure walls in feet, or molasses in quarts. Still the gentlemen who wish this thing done will doubtless be able to provide a way of doing this which will be made public in due time. Meanwhile any one who will devise a scheme whereby the erection of an unpleasant building shall be a misdemeanor, or an offense punishable by law, will be entitled to nothing short of a statue to himself. A community that could legislate against cigarette-smoking might well give evidence of its culture by legislating against unnecessary affronts to public taste. Cigarettes are unquestionably an abomination of the abominations, and the stench they make is quite out of proportion to their size. But however great a nuisance they may be, their odor is not permanent; they may offend us with their presence, but they are not always present. With the ugly building it is very different. The uglier it is the longer it will last, the bigger it is apt to be, the more difficult it is to get away from it. The cigarette is a joy forever compared to some huge, horrid office-building. Yet one is condemned and the other remains with us, to constantly remind us of its horror, to distort our vision, to make us more proficient profanists. Things are not always what they should be, are they?

MINING AND METALLURGY

Conducted by Albert Williams, Jr.

SOMETIMES one poor mine-manager may be better than a dozen good ones. Here is an instance in which the adage that "in a multitude of counselors there is wisdom" does not obtain. Rather should it be said that "too many cooks spoil the broth." If there is any one civil occupation more than another in which unity of decision, authority, and responsibility is essential, it is in the management of a mine or works. It often happens that there are two or more alternative ways in which to reach a given result, and it may be a nice question to decide which to adopt when the arguments for or against either are strong. Now suppose that a board of directors, the superintendent, a consulting engineer, and perhaps some prominent outside shareholders meet to decide upon a line of action,—say the installation of new plant or the kind and extent of underground development. Suppose, further, that each of these men is competent and intelligent. Each will have his own ideas and his own plans to propose, or there may be two or three groups representing so many distinct opinions. The problem is usually complicated by money considerations and policy toward the shareholders, so that there is almost always room for divergent views. Now it might well be that either of two or more plans, entirely distinct, would serve the purpose, and that it would be almost a toss-up as to which should be adopted. Unfortunately the upshot is too often a lame compromise, neither one thing nor another, and operations then go on in a half-hearted sort of way, with inevitable waste of time and money, and with the probability that sooner or later a more radical change will have to be resorted to. Every mining engineer who has acted in an advisory capacity for a company has had to face difficulties of the character here pointed out.

IN order to conduct successfully the affairs of a "company mine," large or small, there must be a systematic organization and a strict division of authority and responsibility, or else everything is muddled and uncertain. The board of directors, so long as they hold office, must have the final say in all matters up to the point where it is advisable to call a special meeting of shareholders to receive authority for making some very serious move. In the current management of affairs they are supposed to be competent and to have the confidence of shareholders, or such a predominating stake in the enterprise that they have a right to dictate. If they go seriously wrong, they can be removed if the outsiders hold enough shares and act in concert. As between the board and the superintendent the relation should be plainly understood. In important matters, involving considerable outlays, the superintendent will submit his projects and obtain approval and authorization to go ahead. In lesser details, however, as for example in ordering work done, hiring men, and contracting for transportation and supplies, he must be the responsible executive officer, if there is to be any system or discipline. When *his* subordinates can go behind his back to the president, or the treasurer, or the board, discipline is at an end. If the board cannot trust him to regulate the general running of the mine or works, let them at once discharge him and get some one in his place in whom they have confidence; but they should never intermeddle with details, or he loses authority and interest. Too frequently the superintendent is looked upon as a mere foreman, and accepts the situation. But a mine in Idaho or Arizona cannot be run from an office in New York or London. Again, as between the superintendent and his staff, if there is any, there must be a definite understanding and a rigid division of responsibility, so that he in his turn can rely on his foremen, millmen, etc., as to certain minor details, while at the same time supervising all, so that he can give his best effort to the larger questions. When a consulting engineer is called in, his position is usually well defined. He has no authority, except perhaps over those detailed to assist in surveys or experiments, and to incur expenses up to a prescribed limit. He submits his advice and projects, explains them, and his duty is done, without interfering with the superintendent's functions.

THUS far we have been considering the American system of mine management, in its most effective shape. There is a modification of this, common with foreign corporations and followed in a few cases in mines and works operated by American companies. It is to have a resident manager or agent, who attends to the business part of the enterprise, the purchase of material, sale of product, accounts, etc., and, by relieving the mine- or mill-superintendent of these matters, leaves him free to manage the technical side. The superintendent then becomes what English miners know as a mine-captain, or a sort of head foreman. Such an arrangement works well in very large undertakings, if the agent and the mine-captain act in harmony and understand each other. The system is not to be recommended for small or medium enterprises, not merely on account of the additional salary, but also because of the introduction of one more possible element of friction. But, in brief, the whole question of mine management resolves itself into the necessity of strict discipline and systematic division of authority and responsibility throughout.

A NEW pressure-blower, suitable for supplying the blast to smelting-furnaces, has lately been introduced. It is of the same general type as the Root blower, but the two interlocking "impellers" are mounted one over the other instead of side by side. The air passes through the machine horizontally, the intake and the outlet openings being on opposite sides. The manufacturers claim that the design is on true epicycloid curves, and that therefore there is a long contact of convex against concave surfaces, with no loss of power from alternate condensation and expansion of air due to irregular contact, and very little jarring or noise. The secret of success with blowers working on this principle is in securing a close fit between the impellers and between them and the outer casing. As to the relative position of the working parts, there seems to be a mechanical disadvantage in setting them vertically, one over the other, while the horizontal direction of the current is perhaps more convenient.

AS computed by the division of mining statistics of the United States geological survey, the total value of the metals produced in the United States in 1893 was $249,981,866, the items ranking in the following order: pig-iron, silver, gold, copper, lead, zinc, quicksilver, antimony, nickel, tin, and platinum. The total value of the non-metallic mineral products of the United States for the same period, and according to the same authority, was $358,835,629; bituminous coal, anthracite, lime, building stone, petroleum, and natural gas leading. Of course it is hardly fair (as was fully explained in the present writer's reports for 1882--1885) to lump together the values of raw products such as coal with those of products in different stages of manufacture, such as the metals; but as a mere matter of curiosity it may be stated that, including some unspecified items ($1,000,000 estimated), the grand total foots up to $609,817,495—which is far beyond the mineral output of any other country, though somewhat below that of the United States in 1890, 1891, and 1892.

By way of comparison, it is interesting to note that the figures compiled by Mr. R. P. Rothwell (in "The Mineral Industry," Vol. II) come out as follows: In 1893 the United States is credited with $267,707,795 worth of metals produced, $371,376,935 worth of non-metallic minerals, and $6,000,000 unspecified—or a grand total of $645,084,730. Both the Survey and M

Rothwell rate silver at its coining, not its commercial value.

Roughly speaking, the value of the crude mineral output of the United States, allowing for deductions for transportation and manufacture, is now somewhere in the neighborhood of half a billion dollars annually. When it is considered in how short a time this great mining industry has grown up, outstripping that of all other nations, the showing is indeed remarkable and offers one excuse for "letting the eagle scream."

THE world's production of gold in 1893, as estimated by Mr. R. E. Preston, director of the United States mint, was 7,523,362 fine troy ounces, of the value of $155,521,700, against 7,077,146 ounces, worth $146,297,600, in 1892, being an increase of 446,216 ounces, or $9,254,100. The world's production of silver also, according to the same authority, showed a gain in 1893 over that for 1892. In 1893 the total silver output was 160,794,100 fine troy ounces, of an average commercial value of $125,419,400, against 152,545,500 ounces, having a commercial value of $133,477,300, in 1892. While the quantity of silver increased, the fall in market price made its total commercial value less for 1893 than for 1892; but comparing the respective coining values, according to the United States standard of $1.2929 per ounce, the figures would be: for 1893, $207,895,400; for 1892, $197,230,500—a nominal gain of $10,664,900. The slight though steady gain in gold, Director Preston thinks, will soon bring the total annual gold output to an equality with that of both metals thirty years ago. But Mr. Preston does not take into account the vastly-expanded business, and consequently augmented demand for exchange, during the same period, which, if considered, would place a different appearance upon the available supply of gold for coinage then and now. Besides, it is not the yearly increment, but the total stock, that affects the coin circulation.

SO much attention and apprehension were aroused by the failure of the 18-inch Harveyized nickel-steel armor-plate tested at Indian Head in May, that the report of the successful trial of another plate on June 12, at the same proving-grounds, will be hailed as a relief. The plate in question was from a lot to be used on the turrets of the *Massachusetts*, measuring 12′ in height, 8′ 3″ broad and 17″ thick, curved to 17′ 5″ radius. Two 850-pound Carpenter shells were fired at it, one with 253 pounds and the second with 393 pounds of powder, at 100 yards. Both projectiles were destroyed, neither fully penetrating the plate, which, however, showed a thin crack to one edge after the second shot.

AMONG several letters referring to a paragraph (in the June issue of this Magazine, p. 425) on the cause of the breakage of stamp-stems and the crystalization hypothesis, comes the following suggestion:

> The next time anyone lays in a set of new battery-stems let him order a few extra lengths of the same stock and cut off enough for test-pieces. Then keep a record of the length of the run and put aside the broken end, and follow this till there are half a dozen ends for samples. These are then to be taken and planed so as to show a square section normal to the stem axis, and the ends are shaped square and both sides and ends polished. Now etch as usual in dilute nitric acid, and take the usual prints from the unused test-piece and from the broken pieces. Put in the testing-machine and get bending and breaking limits of two or three of the broken ends and compare with the unused test piece. Take another broken end and cut it up, by a saw run slowly, into pieces one-half inch thick, with ends normal to the axis of the stem, and polish one facet. Etch, and print. You will then be able to settle the question as far as those stems and that metal are concerned. If any crystalization is shown, take the stem from which the piece is broken, and cut off two feet of the lower end and plane it so as to give a cut through the center along the longer axis. If there is any conversion from fibrous to crystaline structure, the print after etching will show it fully.

IN this connection the *Carpenter and Builder* remarks:

> We do not know that the word "fatigue" properly describes the condition the metal gets into preliminary to breaking, but highly practical grounds exist for the belief that metals become weakened by use even when no incipient

fractures exist. There is a bending or a lengthening and shortening action going on even when the change is too minute for measurement except with exceedingly exact instruments. This movement of the metal causes molecular changes, which reduce the adhesion of the particles, and thereby make the metal weaker. Nearly every observing mechanic has noticed breakages where it appeared that steel or iron originally good had become so brittle and roughly crystaline that it was unfit to sustain an ordinary load. A case occurred some years ago on a well-known railway, which appears to be a good practical illustration of the correctness of theories concerning the fatigue of metals. The company got six new switching-engines that were put into the same hard service in a yard where there was a great deal of running over switches and frogs that subjected the running-gear to severe shocks. The engines were all of the same pattern, strongly built, with unusually heavy axles, the designer believing in a good margin of strength. After these engines had been in the service for several years, one of them broke an axle. An inspection of the fracture showed that what was originally fine fibrous iron had become coarsely crystaline, the molecular change, no doubt, having been induced by the constant jars. Within six months all the six engines failed with broken axles, and the fracture in each instance showed the same condition of the iron.

Some of this "fatigued" metal was reworked and made up into locomotive parts subject to severe strains, and gave good service. This agrees with and bears out the statement made by Mr. W. L. Austin that annealing prolongs the life of battery-stems, and also the experience of millmen who have had broken stems welded and annealed, after which they were serviceable.

THAT wrought-iron and steel do crystalize under long-continued jarring seems to be the almost unanimous opinion of the profession and of the men who make and use machinery subject to such stresses. There is a possible alternative explanation of the failure of metal under these conditions, as explained in the June issue of this Magazine; but unquestionably the weight of opinion, not only of the older authorities but also of the practical men, favors the crystalization hypothesis. The dicta of Wöhler, Weyrauch, Fairbairn, and others, the experiments of Mr. William Metcalf, and much similar evidence, have been cited in its support. The writer has also been shown many letters from machine-shop managers and mill-superintendents, all of whom believe that the best fibrous cold-rolled iron or low-carbon steel, as used in battery stems, and worked up with special care, crystalize under the continuous heavy jarring in service.

ONE metallurgist of experience writes on this head:

> You may object to my statement that wrought iron will "crystalize;" but fifteen years ago people did not dispute that statement as they now do. "Crystalization" may not take place; but *something* happens to the iron—molecular disintegration or weakening of some sort.

This is rather non-committal, and is certainly safe. No one denies the fact that metals deteriorate more or less rapidly under trying conditions, as in the hard usage of the stamp-battery and of parts of other machines most subject to vibration and jar. The question is as to the explanation; and as to that, if a vote of experts were taken on the crystallization issue, there is no denying that the ayes would carry by a large majority.

A MACHINE for testing the behavior of iron and steel under repeated shocks was devised and described by Mr. William Kent in 1879.* The design was to test metals by repeated blows, numbering millions if necessary. The test-piece is a round rod of convenient length and diameter, and the blows are applied in the direction of the length, as in tension tests. A small nut serving as an anvil is screwed or otherwise fastened on the bottom of the rod, and an annular weight is caused to drop upon the anvil by rotating double cams. The weight of the drop being known and the height of fall being uniformly adjusted, each blow gives an impact of the same number of foot-pounds. A revolution-counter attached to the driving-shaft indicates the number of blows given. Mr. Kent's testing apparatus gives what might be called blows of tension; but it could evidently be modified so as to give blows of compression. In that case it would really be a miniature stamp-battery in which the number of drops could be increased, to save time, from the 60 a minute proposed by Mr. Kent, or the 90 to 110 per minute of fast-running batteries, to a speed that would only be limited by the tendency of the rapidly rotating cams to toss the tappets or not clear them. It might be objected that the difference in weight and size between such an apparatus and a regular battery might give different effects. The stamp-battery may itself, of course, be considered a sort of testing-machine on a large scale.

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*Transactions American Institute of Mining Engineers. Vol. VIII, p. 76.

AN exhibition of mining and metallurgy will be opened at Santiago, Chile, in the second week of September. The schedule of sections into which the exhibits will be divided shows that pains has been taken to make this a very systematic exhibition, and it is to be hoped that American manufacturers of mining machinery, motive plant, electrical appliances used in mining and metallurgy, the chemical industries, etc., will be fairly represented. The Chilean government will convey free of charge to the exhibition articles suitable for exhibit, and will also pay the passage money by sea and land of the workmen and operatives whom exhibitors may send for the purpose of setting up and running the machinery and apparatus. Exhibits will be in private bond; that is, if reshipped within twelve months the promissory notes for customs duties will be cancelled. Awards will be in three classes, with medals and diplomas. Applications for space by intending American exhibitors should be made to the Chilean legation at Washington.

CUBA presents an excellent market for American machinery and manufactures, which, though immediately at our doors, has by no means been adequately exploited. The recent installations of coal-handling plant by the Link-Belt Engineering Co., of New York, show that one portion of the field at least is being occupied. One of these plants lately completed near Havana, for unloading and storing bituminous coal from schooners, is the largest coal-handling equipment in the island. Another similar plant is being erected by the same company for the electric-light station at Havana. There should be room for much more American machinery and appliances in connection with the great iron-ore, sugar, and other industries of Cuba.

COMMENTING on the recent German experiments in smelting iron-ore by electricity, the *Engineering and Mining Journal* says that an apparent technical success is shown, but that much is left to be desired from an economic point of view. The inventor, who would naturally make out the best case possible, puts the cost of making pig-iron at $9.65 a ton, with ore at $2.40 a ton, with a possible reduction of $1 or $1.50 per ton of iron with a large plant, when not less than 1000 horse-power is available. Now, as the *Journal* says, a cost of $9.50 or $8.50 for pig-iron in the present state of the market will not leave a margin of profit and induce ironmasters to abandon blast-furnaces and put in a new and costly plant. It is evident that a considerable reduction in cost will have to be made to render the electric smelting of iron a commercial success. These experiments, however, are highly interesting, and possibly point to an entire revolution in iron-making at some time, perhaps not so very distant, when conditions have changed and expenses are lowered. Such a state of things is by no means inconceivable, though not yet in sight.

DURING the twenty-one years ending with 1892 New South Wales produced 121,912 tons of tin, including ingots and tin in ore. The report of the colonial department of mines states that the supply of tin is ample for all home requirements, the deeper lodes having yet been scarcely touched. The manufacture of tin-plates has not yet become one of the industries of the colony.

A COMPANY has been formed in Chicago to utilize some discoveries said to have been made for purifying, hardening, and tempering copper. If the process accomplishes only a part of what is claimed for it, a new industry would be opened. The copper thus treated is said to be much harder and stronger than ordinary commercial copper, to make large solid castings without blow-holes; to make bells; and it is reported that tests at the Washington navy-yard showed not only increased strength but that the metal was pure, unalloyed copper. All this reminds us of the rather mythical process asserted to have been possessed by the prehistoric miners of the Lake Superior copper-region, by which they are supposed to have hardened the celts, hatchets, and other tools made of native copper. This supposititious lost art (which is now pretty generally discredited) has been the object of search by inventors and metallurgists for a long time. It is possible that the new method succeeds in doing what the aborigines are thought to have done but probably never did.. The field has always been an inviting one.

IT is reported that immense beds of nitrate of soda ("Chile saltpeter") have been discovered in Colombia. They are claimed to cover thirty square miles, with a thickness of from 1 to 10 feet, and at a depth of from 8 to 20 feet below the surface. An enthusiastic statement, which must be taken with some deductions, places the quantity "in sight" at over seven billion tons of "caliche," assaying 11½ per cent. nitrate. As these discoveries are said to be on and near navigable streams running into the Caribbean sea, they are much nearer the markets of the world than the Chilean nitrate-beds, so that if the find proves to be at all like what is asserted, it will be of very great importance.

WHILE many forms of portable electric safety-lamps maintained by small secondary batteries have been devised and experimented with, some of which have given remarkably good results, at present the most progress in a practical way for lighting fiery coal-mines by electricity seems to be in the system now quite extensively introduced in European collieries, of using incandescent lamps with double glasses, in circuit with dynamos at the surface; these lamps being used to illuminate main workings and roadways, while some form of oil safety-lamp is retained as a portable illuminant.

AT model German collieries much attention is given to the comfort and health of the men,—lavatories, drying-rooms, and other conveniences being provided. The miners change their clothes before going underground and on coming out, each man having a numbered hook with three branches on which to hang his clothes, and these hooks can be drawn up to 12 or 15 feet above the floor. In this way the clothes are dried and aired rapidly by steam coils, are kept safe, and the ventilation, heating, and supervision of the change rooms regulated and cleanliness promoted.

MANGANESE ore was produced by five states in 1893—Arkansas, California, Georgia, Tennessee, and Virginia—while in the preceding year only Arkansas, Georgia, and Virginia produced manganese ore. The output of these three states declined, while California and Tennessee together yielded only 882 tons in 1893.

TAMARACK copper-mine, Michigan, continues to hold the record for deep mining. No. 3 shaft had, on May 18, been sunk to 4020 feet vertically, and No. 4 to 3915 feet. By the time this note is printed both shafts will have made considerable progress. These two shafts are now the deepest of any in the world.

SOMEONE having called Cochiti, the new gold and silver district of New Mexico, a "poor man's camp," the *Prospector* grimly remarks that "this may be said with emphasis of all silver-mining camps just at present."

THE total value of the mineral production of Canada in 1893 was $19,250,000, a quarter of a million less than that for 1892.

CIVIL ENGINEERING

Conducted by John C. Trautwine, Jr.

STRUCTURES which are meant to maintain wide differences in pressure between great masses must be wisely and skillfully designed and constructed, and afterward carefully inspected. Even then disasters may occur—disasters proportional to the intensity of the pressure, to the masses involved, and to the suddenness of the outburst. This is true, not only of engineering but of social structures; not only of reservoir embankments and steam-boilers, but of those economic systems which permit and encourage the development of sharp contrasts between wealth and poverty. A structure inherited from a past order of things and ill-adapted to the changed conditions of the present is morally certain to go out, and the valley must take the consequences. It may be very reprehensible for the particles under pressure to move as they do, but it is well for those in charge of the structure to observe the facts, as indicated by history, and to design accordingly.

It is hardly to be expected that a jet, escaping from the lower portion of a high and leaky dam, should pursue that course which to a dispassionate observer might appear the best adapted to accomplish its own purpose—if purpose it have; and so it is perhaps not to be wondered at that presidents of republics, as well as emperors, occasionally fall victims to the bullet or knife of the assassin. In Sadi Carnot the community loses, not only the president of a republic, but an engineer of education and experience, and the descendent of one who, as a mathematician, made the name of Carnot immortal. Those Americans who, in 1889, received the courtesies of the French engineers in Paris, will mourn his loss as one personal to them.

THAT the annual conventions of the American Society of Civil Engineers are enjoyable occasions, goes without saying. The place of meeting is usually so well chosen that the mere outing which the convention affords is in itself a treat; while the pleasure of again grasping by the hand the friends whom one has so pleasantly met a year (or perhaps a score of years) before is a far greater one. But the convention recently held at Niagara Falls will, we think, pass into history, not only as one of the most largely attended, but also as one of the most enjoyable of these occasions. The magnitude of the attendance was chiefly due, no doubt, as we have already hinted, to the wise selection of a site not too far from the center of mass of the membership; while the beauty of the spot and the unusual interest of the engineering works to be seen there readily account for the fact that, in spite of the prevailing hot weather, those who took part expressed themselves so generally as being delighted with their experience. The special day train of Pullman cars, placed at the disposal of the members by the courtesy of the Lehigh Valley Railroad Co., was well filled by members and guests from New York and Philadelphia and from points beyond, and gave them perfect facilities of enjoying not only the beauties of the Lehigh and Wyoming valleys, but also those of the new short line running from Van Etten Junction to Geneva along the high ground just back of the east shore of Seneca Lake.

Not a little of the enjoyment of those who faithfully attended the meetings of the convention was due to the eminently sensible suggestion of President Craighill, at the opening meeting, that the papers should be read in abstract only. It seems unpardonable to inflict upon an audience the reading at length of a technical paper, copies of which are already in the hands of all interested hearers, and it is devoutly to be wished that this imitation of the practice of the American Society of Mechanical Engineers may become the rule rather than the exception, with "the Civils."

PRESIDENT CRAIGHILL, in his annual address, enlarged upon the subject of coast-defense, holding that guns and land batteries have always the advantage over ships, however heavily armored, so that, as the soldier has dropped his armor and has come to rely solely upon the efficiency of his armament, the near future may see our battle-ships stripped of their heavy plating, and adapted rather for offense and for flight than for resistance by means of their walls, realizing the remark of Admiral Farragut that broad-sides are better than iron-sides. Colonel Craighill expressed the hope that the Nicaragua canal might be speedily completed, and that under the control of the United States, in order that our vessels may have ready and undisputed passage from the Atlantic to the Pacific and vice versa. He emphasized also the importance of establishing a system of land-locked communication between New York bay and the Gulf of Mexico by means of the series of bays and inlets which line our Atlantic coast in an almost unbroken succession between the waters named, a scheme which, as already remarked in these pages, formed one of the favorite projects of the late Captain Spencer C. McCorkle.

The presidential address was followed by the reading of a very elaborate paper prepared by Dr. Coleman Sellers, and describing the works of the Cataract Construction Co.

AFTER visiting these works and those of the Niagara Falls Paper Co., where the turbines designed by Mr. E. Geyelin, constructed by R. D. Wood & Co., of Philadelphia, and described in these columns in May last, were seen in operation, the party proceeded to the works on the cliffs of the Niagara river below the falls, where are located a number of mills taking their power from the old hydraulic canal of the Niagara Falls Hydraulic Power and Manufacturing Co., completed in 1861. This canal, leaving the river above the falls, not far from the point where the new development takes its water, passes behind the town of Niagara Falls and delivers its water to the mills referred to. Here it passes to turbines placed at the bottoms of pits excavated in the cliff near its brink, acting under a head of about 100 feet and discharging their waste water into the river below, in a large number of picturesque little falls of something like 100 feet in height. One of these discharges has, however, been harnessed and put back to work again, being led through an inclined iron flume, 8 feet in diameter, to the wheels of the pulp-mill of the Cliff Paper Co., which was built within the last two years upon the lower river bank near the water's edge. This plant was described in a paper read before the convention by Mr. Wallace C. Johnson, the engineer of the canal company.

TO the well-regulated British mind no idea is more distasteful than that of innovation, however peaceably accomplished, except that of innovation accompanied by an uprising of "the masses." If those opposed to a suggested departure from established methods have any fear of its prevailing in spite of the national conservatism, they have but to show that in other countries such departure has happened to be coincident with revolution, and its doom is practically sealed.

And so we find the chancellor of the exchequer gravely pointing out that this has been the case with the metric system, and that notably in Germany the adoption of that system took place in troublous times and as the result of a great war and of those developments which led up to the unification of Germany.

With our British brethren, naturally predisposed against the innovation, this sort of thing may well be expected to pass for argument; but Mr. J. Emerson Cowson, member of the Institution of Civil Engineers and chairman of the executive committee of the new Decimal Association, now contributes to the *Chamber of Commerce Journal* a paper on metric weights and measures, in which he undertakes to refute the statement of the chancellor of the exchequer. From this paper it appears further that the Associated Chambers of Commerce and the new Decimal Association have now resolved to press the adoption of the metric weights and measures, and that a petition praying for the appointment of a select committee to consider the subject has been presented in parliament with the signatures of a large number of influential members.

WHILE little or nothing is now heard of the late Captain Eads's projected ship-railway across the isthmus of Tehuantepec, and while, on the other hand, various schemes for the resuscitation of the ill-fated Panama canal are ventilated from time to time, the matter of the Nicaragua canal, to which we have already referred as being mentioned in Colonel Craighill's annual address before the American Society of Civil Engineers, is receiving renewed attention. In April last the senate committee on foreign relations reported favorably upon a bill guaranteeing $70,000,000 bonds of the Maritime Company and leaving 70 per cent. of the entire capital stock of the company in the ownership of the United States and 16½ per cent. in the treasury of the company; and a special committee has been formulating a new bill providing for governmental control of the canal. The fact that the St. Mary's Falls canal, connecting the waters of Lake Superior with those of the lower lakes, has for three years out of the last four passed a tonnage greater than that of the Suez canal, is urged as evidence of what may be expected from the construction of the Nicaragua canal.

THE report of Mr. Desmond FitzGerald, resident engineer, in the annual report of the water-supply department of the city of Boston, for 1893, states that, owing to insufficient storage-capacity, the color of the water supplied to the city has been increasing somewhat during the last two years, and much space is accordingly devoted to the investigations now being made at the biological laboratory at Chestnut Hill upon the colors of the various waters supplied. The color is found to be derived chiefly from swamps on the Sudbury-river water-shed, a source which it is proposed to attack by draining some of the swamps. Weekly examinations of the color are made by means of the platinum standard recently suggested by Dr. Allen Hazen, in which the color of a water is designated by the amount of platinum, which, in acid solution, with so much cobalt as will match the hue, produces an equal color in distilled water. The nesslerized ammonia and natural water standards formerly used at the filter-station have been found to be of very little value for accurate color, readings, and Dr. Hazen's platinum standard has accordingly been adopted for use in the filtration experiments.

With the true Bostonian tendency to originality, the department has also departed from the old method of giving the number of organisms per cubic centimeter of a water, and has substituted the proportion of a standard area seen to be covered by such organisms and by amorphous matter. The new method has this advantage overthe old, that it takes into account the dimensions of the organisms, and it is claimed that, if proper judgment isused in estimating the thinness and thickness of organisms, the new unit will have substantially the same value as a unit of volume.

THE last report of the Boston city engineer, Mr. William Jackson, devotes much space to the matter of the corrosion of water-pipes by electrolysis from the return currents of electric-railway lines, and embodies a report by Messrs. Stone and Webster, electrical engineers, who were detailed to investigate and study the problem. The only cases of electrolysis of water-pipes distinctly traceable to the action of such currents were those of lead service-pipes in the vicinity of the power-station of the West End Street Railway Co. on Albany street. Here a measurement of the differences in potential between pipes near the station and others at more distant points, differences plotted in two diagrams furnished with the report, show incontestably the presence of electrical action such as may very fairly be suspected of being the source of the trouble, but the engineers hesitate as yet to pronounce positively that the injury proceeds entirely or chiefly from this source, or that the corrosion noticed is a serious factor in shortening the life of the piping system as a whole or of any part of it in particular. They strongly incline, however, to the opinion that serious corrosion may be now proceeding.

The department complains of constant trouble from the submerged water-pipes in Boston harbor. These are liable to freeze in exposed places at low tide and to be disturbed by currents in the channels, and the department therefore urges the construction of storage-reservoirs upon the islands. It is claimed that the new 20,000,000-gallon high-service pumping-engine built by N. F. Palmer, Jr., & Co. (New York), at the Chestnut Hill station, is "the best pumping-engine in the United States." Like other cities, Boston has felt the necessity of looking about for an increased source of water-supply, and the State Board has been investigating the Nashua river above Clinton, whence it is believed that a sufficient quantity of good water could be procured to supply all the communities within a radius of ten miles of the state house for many years to come.

THE report of the street department shows that with characteristic conscientiousness the city of Boston has been exercising itself over what it terms its smoke nuisance, although one would suppose that by virtue of its relative proximity to the anthracite-coal regions, it should enjoy considerable immunity from this trouble as compared with western cities. By authority of an act of the legislature passed in May, 1893, and requiring that at least 75 per cent. of all smoke produced shall be consumed or suppressed, the mayor directed Mr. Henry H. Carter, superintendent of streets, to see to the enforcement of these provisions. An investigation was accordingly instituted by that official, who finds that most of the nuisances developed result from insufficient air-space and chimney capacity and from forcing of the draft. In this latter respect, the electricians again appear as the chief offenders, for many of the most serious smoke nuisances of the city are caused by the fires under boilers furnishing power for electric-light dynamos, the draft being forced at the hour when the lights are turned on. The superintendent believes that "no matter what style of combustion chamber is used, or what device for smoke-prevention is added thereto, if an irresponsible and careless fireman is employed, no good results can follow."

An interesting comparison of Boston with other cities in the matter of street paving shows that Boston makes up for some of her progressiveness in other matters by being rather conspicuously behind her sister cities in this respect. In February of this year she had less than six miles of sheet asphalt, as against nearly 212 of Telford and MacAdam and 136 of gravel, while even in non-progressive Philadelphia there were eighty miles of sheet asphalt, or over 9 per cent. of the whole system, and in Buffalo 38 per cent., or 150 miles, were of this material, making an asphalt mileage said to be equal to that of all the cities of Europe, where this system of paving has been in use for forty years. The inferiority of the Boston pavements is found to entail a very heavy expense for street cleaning.

As a measure of relief to the unemployed, a number of sewers, aggregating about 14,000 feet, which would not ordinarily have been built during the winter, were constructed, and were in part paid for out of the fund raised for the benefit of such persons.

The report states that the main drainage-works, constructed some ten years ago, have ever since been working in an unfinished condition, and consequently at great disadvantage. Attention has been repeatedly called to this condition of affairs, but the necessary appropriation for the completion of the works has not been forthcoming. The bills for repairs are correspondingly heavy. Work on the gates and frames in the discharge sewer brought to light an interesting example of the action of sewer-gas upon mortar, as compared with that of the sewage itself. The mortar between the bricks above the surface of the sewage was eaten out to a depth of an inch, while that below the surface was intact.

To judge from the remarks here made upon the use of dynamite, the reader might suppose that the employment of that material for blasting was a matter of recent introduction; for considerable trouble has arisen from accidental explosions, arising chiefly from efforts to warm the material for use in cold weather. A common practice is to heat the cartridges in the pine boxes in which they come packed; but a box, if used for some length of time, becomes in itself a source of danger, the wood becoming saturated with the liquid nitroglycerine and sensitive to concussion.

The report contains a complete compilation of all laws and ordinances under which sewers have been built in the city of Boston, beginning with an act passed at the session held at Boston in 1709 for "regulating of drains and common shores" (sewers). This ancient act was designed to regulate the same difficulty in the way of the breaking-up of streets for the laying of such drains, etc., as is experienced in most cities at the present day.

MR. ELMER L. CORTHELL, late chairman of the general committee on the International Engineering Congress, to whose suggestion for the formation of an International Institute of Engineers we referred in THE ENGINEERING MAGAZINE for June, has now formulated a proposition for this purpose. The principal objects of the proposed Institute, which is to be called the International Institute of Engineers and Architects, are the provision of a suitable channel for the international exchange of information respecting engineering and other works and discoveries, and the conduct of tests of materials and the publication of the results of such tests through the channels of the Institute. It is proposed to admit to fellowship in the Institute "any person engaged in the profession of engineering or architecture, of mature age and of good character." The governing bodies are to be national boards of direction, with an international board of direction and an international executive committee. The dues are fixed at $10 (or equivalent) per annum. The papers and discussions, after final approval by the executive committee of the international board, are to be edited monthly and supplied to each fellow. The Institute is to be divided into eight divisions, corresponding to the departments of civil, mining and metallurgical, mechanical, electrical, marine and military engineering, engineering education, and architecture. The proceedings are to be printed in English, French, German, and Spanish, each fellow to be supplied with the proceedings in the language specified in his application for fellowship, or subsequently. Both metric and English measures are to be given in each paper and in the discussion. It is proposed that the general office and domicile of the International Board and of the Institute shall be in the United States, but the particular city is not specified. The first congress of the Institute is to be held in Paris in 1900, and quinquennial congresses are to be held thereafter, the place of each to be determined by the one preceding it.

IN THE ENGINEERING MAGAZINE for March reference was made to the elaborate series of experiments upon the flow of water over weirs, conducted by the great French hydraulician, M. H. Bazin. Three series of these experiments had then been published, concerning themselves respectively with vertical weirs over which the water flows in a perfectly detached sheet, with inclined weirs and the determination of the pressures and velocities within the falling sheet, and with cases where the sheet hugs the face of the weir, the air being prevented from entering behind it. In the fourth series, the account of which in separate form is just at hand, the distinguished author pursues his investigation of cases of the kind last named, with special reference to the effect exerted upon the fall and upon the velocities and pressures under and within the falling sheet, by changes in the level of the down-stream surface. This series completes the study of weirs with sharp crests. In the fifth series the investigation will be extended to cases of flow over wide-crested weirs. During the progress of these experiments upon weirs, the same indefatigable investigator has been engaged upon similar researches into the behavior of jets issuing from vertical and horizontal orifices of different forms. In these, as in the weir experiments, M. Bazin has availed himself of that extremely delicate instrument, the Pitot tube, as elaborated by Darcy, and has, by its means, explored the interior of the issuing vein and determined the pressures and velocities at different points of its interior.

As a result of these studies, M. Bazin finds that, in streams issuing from vertical orifices, the minimum velocity occurs a little above the center of the orifice, and that the coefficient of flow through a rectangular orifice flush with the bottom of the reservoir, extending across its entire width and prolonged down-stream at its ends by boards which prevent the divergence of the outflowing stream, is 0.626, or at least 0.02 greater than for circular or square orifices of the same height. Poncelet and Lesbros had pointed out that the velocity through the contracted vein of a jet issuing through a square vertical orifice is somewhat greater than the theoretical velocity. M. Bazin, while recognizing this, inclines to attribute it to the fact, just noticed, that in such orifices the minimum velocity is found, not at the center but somewhat above it, a peculiarity due, no doubt, to the action of gravity in increasing the velocity of the filaments below the center. Investigating the profile of a jet issuing from a vertical orifice M. Bazin finds that the curve formed by its axis falls somewhat within or below that described by a heavy body issuing horizontally with the same velocity, and accounts for this by the action of the resistance of the air upon the entire surface of the liquid vein.

A committee of the Institute of France, reporting upon the memoir in which M. Bazin discusses these results, unanimously asked its insertion in the *Recueil des Savants étrangers,* a collection embracing the researches of Poncelet and Lebros, of Poiseuille and of Darcy, and the earlier contributions of M. Bazin himself. The recommendations of the report were adopted.

Mr. Clemens Herschel, finding that the development of hydraulic works and the corresponding improvement of the country are impeded in default of a provision extending to enterprises of hydraulic engineering the same right of eminent domain enjoyed by enterprises connected with matters of transportation, seeks to have such a provision introduced into the constitution of the state of New York. He has accordingly issued to delegates to the constitutional convention a circular setting forth the merits of the case, and pointing to the fact that the constitutions of eight of our states already contain such provisions, while in other states laws have been passed granting such powers. Land, he claims, is now held in parcels too small to permit of its taking by private purchase, as was done in the days when the great manufacturing towns of New England and of New York state were started; and the necessity for such a movement as is here contemplated has been rendered far more urgent by the introduction of electric power-transmission, by which water-powers may readily be rendered available at great distances from their sites.

The Hennepin canal, which is to connect the Illinois river near its great bend with the Mississippi near Rock Island, crosses the intervening divide by an elevation of over 200 feet, necessitating a formidable succession of locks; and, as good stone for the masonry was not obtainable in the neighborhood, it was decided to use concrete exclusively in the work now in hand. This work was described in detail in a paper read by Mr. J. W. Woerman in a paper recently read before the Engineers' Club of St. Louis, and in which it was claimed that this will form one of the most extensive pieces of concrete construction yet undertaken in the United States.

MECHANICAL ENGINEERING

Conducted by Henry Harrison Suplee.

ONE of the most interesting features of the Engineering Congress last year at Chicago was the closing session, when the representatives of the various branches of the profession from all other parts of the world gave greeting and farewell to their brethren in the United States. On that occasion an incident occurred which may prove almost the counterpart of the historic "*billig und schlecht*" criticism which Professor Reuleaux made at the Philadelphia Centennial, and which, while due to a misunderstanding of the words of the same honored professor, may result in consequences of much value in more directions than was at all intended at the time As is well known, Professor Reuleaux spoke with evident appreciation of the wide extent to which the use of measuring instruments of high precision existed in American shops, and, through the misinterpretation in Germany of an imperfect report of his remarks in an American journal, he soon found that he had stirred up a "tempest in a tea-pot" among his countrymen and that he was charged with making the broad assertion that America was far ahead of Germany in the entire matter of mechanical measuring appliances. Professor Reuleaux did his best to explain the matter, but without success, and he has now replied to his detractors in a manner which may lead them to regret their action. In a pamphlet, an advance copy of which is before us, he goes most thoroughly into the entire subject of the state of the science and practice of exact measurements in this country. He takes up the gage of battle and proceeds to show that Germany really has much to learn upon this most important subject.

"I have been forced," says he, "by the attacks here to lay before my engineering countrymen the clear state of the measuring question in Germany. I would have preferred and had the intention to give descriptions of the American progress gradually, as that would have been much the better plan. Now my antagonists have forced me to show how very far we are behind. There is no doubt that we will come to the front again when all the advantages of excellent measuring are understood. It was very hard for me to be forced to say what I have said but it was not to be avoided after the excitement which my antagonists had provoked."

This is plain language, but Professor Reuleaux knows whereof he speaks and, indeed, we have nowhere in English such a complete and compact record as he gives of the present status of the subject. His fully-illustrated pamphlet is almost important enough to warrant translation for reference here. The spirit of national pride is nowhere stronger, however, than in Germany, and we may feel very sure that the clear presentation which this pamphlet has given to German engineers and machine-tool builders of American methods and devices, together with the quiet but forcible prodding which is involved in the inevitable comparisons and which compel one's attention, will result in an immediate and rapid advance in this matter in Germany which may make Americans look to their laurels.

WHILE not altogether within the scope of a department of Mechanical Engineering, yet it may be of interest to those of our readers who have the privilege of a personal acquaintance with Professor Reuleaux to know that he has expressed his appreciation of America in another manner, namely, by translating into German Longfellow's poem "Hiawatha"! This has just appeared in a dainty little volume, the translation being most poetically done in the exact versification of the original, and the accompanying notes by the translator evince a familiarity with the spirit and beauty of the original poem which shows that the Professor's engineering studies have not taken either poetry or romance out of his nature.

WE have frequently referred in this Department to the advantages and growing appreciation of graphical methods in calculations for mechanical work. These are, of course, much used in such work as the construction of strain diagrams, etc., but it is the use of graphical calculating-machines, if they may be so called, that we now have in mind. The slide-rule is as old in principle as the days of Gunter, but its growing use in the drawing-room and field is much more recent. Many years ago the late Mr. John W. Nystrom, a man whose ability never met with proper recognition, invented a calculating-machine based upon the principle of the logarithmic spiral, but it was too expensive to be available for general use, although he himself demonstrated its value and utility. The more recent forms of slide-rule give results which in most cases are quite accurate enough for all practical purposes, and, even where the result is desired to a greater degree of precision, the slide-rule gives an independent check which is most reassuring. In many cases much labor may be saved in preparing tabular work by calculating only a portion of the results and plotting these as ordinates through which a curve, carefully drawn by means of a flexible spline, will enable the intermediate values to be determined with a degree of precision limited only by the practicable scale of the diagram and the skill of the operator.

A novel and most ingenious form of slide-rule has been devised by Mr. J. W. Sexton, of Philadelphia, and those who know the mathematical attainments of this gentleman and his familiarity with what has already been done in this field will be prepared to receive with much interest the announcement of completion of this valuable aid to the engineer.

REFERRING to the interesting communication of a correspondent in the last issue of this Magazine, commenting upon some points made in this Department about aërial navigation, there is no doubt that close imitations of nature are not always the best methods for mechanical devices, and this is probably as true of navigation in the air as it has been in the water. We do not propel our vessels exactly as if they were fishes, and we shall probably not fly in machines closely resembling birds. At the same time, the low efficiency of screws as applied to lifting and propulsion of airships has been demonstrated to an extent which will probably compel the use of some form of supporting aëroplane in connection with them if they are to be used with any degree of success. As noted by the writer in reviewing some recent works on this subject in the last issue of this Magazine, neither screws or wings give results which warrant their use alone, and while we should not attempt to imitate the bird too closely as an actual model of construction, yet it must not be forgotten that the bird *can* fly, and that thus far man has not succeeded in performing that desirable feat to his entire satisfaction, and that we should not despise any points which may be obtained from our feathered companions who may not be exactly laughing in their sleeves at our efforts, but who doubtless would be doing so had they those modern capacious articles in which to conceal their amusement.

LABOR disturbances of any sort are usually followed by numerous panaceas which are offered to prevent such difficulties from occurring in the future, but until all labor is performed by machinery the element of friction will probably exist in the personal sense as well as in the mechanical. There is one phase of modern mechanical development, however, which may have an economic importance not altogether at present appreciated in this very matter of employer and employé. The modern methods of transmission and subdivision of power may result in the decay of the factory system and restore, in great measure, the status of the individual workman, while at the same time retaining for that workman the same efficiency as is now possessed by him in the great workshop. The necessity of concentration of power in order to obtain highest efficiency has been the real reason why the individual workman, with his own shop and personal control of his own product, could no longer compete with the great organizations which can only be possible with organized capital. Should each man become his own employer again, however, with ample power at his command, as he now can command light, heat, or electricity, he may strike or lock himself out, or do as may please him, but if he has a fair measure of common sense and ability he will do neither but work for his own profit and become the measure of his own value to himself.

MUCH has been written about the regulation of steam-engines and many are the ingenious devices which have been made to insure close regulation, particularly for engines for use in connection with the generation of electricity. The varying conditions under which engines for this branch of work are compelled to operate are not always appreciated and unsatisfactory results sometimes follow, which may be due simply to lack of consideration of the conditions in question. The writer has recently had occasion to notice the operation of a small trolley line and to remark upon the convulsive efforts of the engine to take care of the suddenly varying loads cast upon it. The line, being a short one, was started with but two motor-cars, but these are at times heavily loaded, and it is most apparent in the neighborhood of the power-house whenever a car is stopped or started on the road, simply by the heavy puffing of the exhaust and sudden laboring of the engine for a few minutes after. This called attention to the fact that, there being but two cars, the fluctuations in the load were much greater than if there were several, as the average work would be much more uniformly maintained if carried to a greater degree of subdivision. As the service increases this will doubtless modify the action, but the motive power, which has probably been installed with future conditions in view, is now struggling with present conditions, and is having a hard time of it.

THE question of the efficiency and capacity of coil boilers has recently had given to it additional data for a favorable answer by the unusually high results which have been attained by the latest Thornycroft torpedo-boat-catcher *Daring*. This boat, which was guaranteed by Messrs. Thornycroft to make a speed of 27 knots per hour, exceeded this guarantee in a most remarkable manner, the average speed of three runs over a measured mile, with and against the tide, being 28.268 knots, and the last ot the three runs, although against the tide, was made at the rate of 29.268 knots per hour! While this marvelous result is doubtless due to the entire combination of points, all of which must have contributed to the speed, yet it is worthy of note that the coil boilers furnished ample steam throughout the run, and that the safety-valves were blowing for a portion of the time. Of course no one doubts that coil boilers are excellent steamers and the points about such boilers which have been subject to criticism have been rather those of durability and accessibility, but if the main point of steaming capacity can be demonstrated to be so superior for this type as the above trials seem to indicate, there can be little doubt that the proper application of intelligent study and experience will enable the other debatable questions to be settled beyond controversy for both large and small boilers, and that too without impairing the capacity of the boilers for their real object,—*i. e.*, the making of steam.

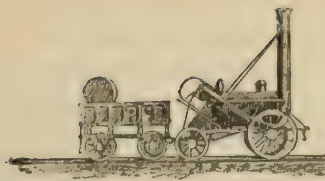
AMONG the many interesting features of the Montreal meeting of the American Society of Mechanical Engineers the attraction offered by the Reuleaux collection of mechanical models at McGill University is especially worthy of note. Although this is the most complete set of the Reuleaux models on this side of the Atlantic, yet it does not comprise all the beautiful examples of the model-maker's art which may be seen in the magnificent series at the Berlin Polytechnic, but no one who has seen even a portion of these models can fail to be convinced of the fact that it is by such means that instruction in kinematics can best be conveyed. When the nature of a kinematic "chain" is once impressed upon the mind through the medium of the eyesight it is almost impossible for the student to misconceive the relation of parts in subsequent combinations, and it is to be hoped that the use of models will extend more and more in this and other branches of instruction. The practical mechanic finds actual working models all about him in his everyday work, and whether he will or no he is obliged to take into account all the functions of the various pieces of mechanism with which he has to deal, so that there can be none of that convenient "neglecting" of quantities or values which the student may intend to determine at some more convenient season. A man educated in the midst of such constant demonstrations as are given by the mere presence of such models as those at McGill cannot fail to be far more practical, while none the less theoretical, than the student who has followed the usual analytical methods, and the combination of both cannot fail to produce most excellent results.

THE accounts which have been received from England of the manner in which Mr. Hiram Maxim's imitation of Herr Dowe's "bullet-proof" cuirass has excited the ire of the military gentlemen who have been made a laughing-stock by the ingenious American, are decidedly amusing. That Herr Dowe has made a cuirass which offers resistance to bullets seems to have been fairly well demonstrated, and when Mr. Maxim declares that he can do the same thing off-hand and offers to give a public exhibition, crowds of interested individuals, both civil and and military throng to see the show. When it appears that Mr. Maxim's "cuirass" is practically nothing more than a quarter-inch plate of the finest steel, the indignation of the crowd, which conceives itself "sold," is great, and Mr. Maxim barely escapes being mobbed. The amusing feature about it all is that the steel plate, which gives equal resisting capacity with the German fabric, weighs somewhat less per square inch than the latter material; and that, notwithstanding this most apparent fact, Herr Dowe protests vehemently, in print and otherwise, that there is no steel in his cuirass. It is possible to sympathize to a limited extent with scientific men who have been gravely testing the German invention, in view of their feelings when they discovered the little point which Mr. Maxim has brought to their notice, but it is difficult to maintain a straight countenance when one thinks of the solemn Germans, objecting to the use of anything so *unwissenschaftlich* as steel, after all the learned discussions which have been given to the new material, even though the latter may be no better than steel and rather heavier.

A CONTEMPORARY journal attempted in a recent issue to enlighten the "public mind" as to the question of the real meaning of the term "knot," and went to some trouble to explain that a knot is not equal to a mile, which indeed is quite true, but in its further effort to impart information it proceeded to state that a knot is 6082 feet long! This confusion of a knot with a geographical mile is not uncommon among landsmen, and indeed is frequently found existing in the "public mind," but the editor of a technical journal should know that, properly speaking, a knot is not a distance at all, but is a *rate of speed!* The only possible sense in which a knot can be considered as a length, is when the distance between two knots on the log-line is meant, which is something quite different. To call a knot a distance of 6082 feet, is about as correct as to call a horsepower 33,000 foot-pounds, the omission of the time element being an error of equal importance in both instances, and, although some of the older dictionaries commit the error of confounding a knot with a nautical mile, yet the later works, which aim at some degree of correctness in definitions of technical terms, are more accurate, and surely a journal which professes to enlighten the public mind should be more careful in such matters.

THE present status of the armor-plate question bids fair to perpetuate the old logical paradox of the result when an irresistible force meets an immovable resistance, and the solution of the problem seems to be no nearer than it was in the memorable days of Jules Verne's "Baltimore Gun Club." No sooner do we hear of the great success of a test armor-plate than it is followed by the triumph of an armor-piercing projectile, and so the contest will go on until the limit of one or the other is reached. Not so very long ago it was thought that the maximum gun capacity had been reached, but to-day we have guns of much lighter weight with far higher "power," while on the other side improved methods of hardening and the use of nickel alloys have enabled armor-plates of far higher resisting capacity to be made than was formerly supposed possible within practicable limits of weight. It still seems probable that the result will ultimately be the same as it was with armor for man and horse, and that the increase in armor protection will go on and on, until the actual limit is reached, when it will suddenly be abandoned entirely, to make way for speed, agility, aerial warfare, or possibly—disarmament?

THE success which has attended the official trial of the *Minneapolis* is a most satisfactory confirmation of the wisdom of the adoption of triple-screw propellers for fast cruisers, and Mr. Melville is to be congratulated upon the demonstration of the correctness of the faith he has put in this construction. While the greatest argument in favor of the triple screws has been the practicability of using the middle propeller for moderate speeds at high economy, at the same time retaining the enormous power of all three engines and propellers for the high-speed use in commerce-destroying, this has been shown to be only one of the advantages. The *Columbia* showed a decided fuel economy over that of the twin-screw cruisers, as well as increased speed, and the full reports of the detailed performance of the *Minneapolis* will be awaited with interest for additional information upon this point. The merchant marine waited the results of twin screws in naval service before adopting them on the Atlantic lines, but now, in spite of the excellent performance of the single-screw *Umbria*, twin screws are considered the only proper thing for fast transatlantic service. The records of the *Columbia* and the *Minneapolis*, however, lead us to believe that before long triple screw steamers will be winning new records from Sandy Hook to Roche's Point, and that twin screws will have to take second place. The great increase in power which must be provided has caused some parts of the engines to surpass practicable machine-tool limits, but when three engines, driving as many propellers are used, it is possible not only to keep the parts within reasonable dimensions but also to triplicate much of the work, thus permitting many economies in first cost of construction. We have spoken elsewhere of speed and of armor, and in our new navy we have both, and it is not out of place here to call attention to the paper by Engineer-in-Chief Melville, in another part of this Magazine, upon "The Modern Battle-Ship as a Fighting-Machine," and to the rapid manner in which the engineer is superseding the sailor as the operator as well as the constructor of a "man-o'-war."



RAILWAYS

Conducted by Thomas L. Greene.

RAILWAY questions, during the past month, have been overshadowed by the strike of the employés against the roads using Pullman cars. The merits or demerits of the dispute at the town of Pullman have been lost sight of in the face of the much greater problem presented by the general strike. Finding the business of car-building dull Mr. Pullman proposed to his employés a reduction in wages. They apparently consented, whereupon Mr. Pullman accepted contracts for cars at prices so low that on that particular work he lost something on each car. The indirect benefit to the men consisted in that the Pullman company thus afforded them work during a season of depression, though at a reduction below their regular wages. Mr. Pullman's object was, however, not philanthropical; he no doubt was willing to lose a little money if he could keep his town occupied, his plant in order, and his skilled workmen attached to his shops, in order to be ready when business revived. For this he expected such an inflow of orders as would more than make up his past losses. Though the men had apparently accepted the reduction after the contracts were signed they refused to work longer, demanding the increased pay. This Mr. Pullman refused and still refuses to grant. Following this local dispute came the order of the Federation that a general strike should be declared against all companies which used Pullman cars.

WHATEVER judgment one may pass upon the justice of the original demands of the Pullman employés, it is clearly evident that a general stoppage of trains is not a proper way to settle that question. So important is the service rendered by the railways that not only are our modern complex commercial conditions dependent upon transportation for their continuance, but the people of many states must rely upon the railways for bread and meat. In short, our present civilization could not exist without interstate railway commerce. It is monstrous, it is unbearable, that our whole trade should be thrown out of adjustment, in order that a wage settlement, concerning but a few men comparatively, should be forced. The railways could not yield this point; they must fight the fight out for the good of the whole community.

FOLLOWING the precedent set by Judge Jenkins in the Northern Pacific cases, the courts granted injunctions against interfering with the trains. That judge called a combination to quit work on the part of railway-men, a conspiracy to cripple the running of the railways, and, therefore, in the nature of the case, criminal. A trainman or switch-man is bound by the equities of his position. The sailor cannot stop work in midocean, nor the pilot in midstream, nor the policeman while making an arrest, nor the surgeon when in the act of performing an operation. If the running of trains is a necessity of civilization—and even the courts are adopting that view—the railway employé has no more moral right to stop them without notice at the bidding of his trade-union, than has the sailor or surgeon to quit work at any moment. These injunctions are based upon some such idea. But before we can say exactly what line the new theory will take, we shall have to wait for the opinion of the United States supreme court, to which august tribunal the Northern Pacific case was appealed. The calling out of the United States troops was in line with that theory. There is law and precedent for President Cleveland's action. Nor does it violate the spirit of the constitution. When our forefathers conceded to the states their local authority they did not mean to cover cases where local authority concerned other states. Massachusetts is dependent upon Dakota for bread; it would be a subversion of the spirit of the law if by enactment or failure to enact on the part of the state of Illinois, this flow of breadstuffs across the state should be interrupted. In this view not only is federal interference justified by the existing statutes, but not to interfere for the protection of interstate commerce would be to lose sight of the very thought of the constitution which intended to prohibit the stoppage of trade across state lines by reserving its regulacion to congress. Trade has outgrown state lines and the law-making and the law-executing powers must advance with our business progress and be molded by it.

IT is very much to be doubted whether Mr. Pullman's experiment of a town controlled by his company should have been undertaken. It smacked too much of paternalism and gave the employés a chance to say that Pullman was bound to take care of them, since their wages gave a profit to the company in the shape of rent, gas- and water-charges, and the like; and that since the Pullman company as a whole was prosperous enough to continue the old dividends it should pay old wages. Not a convincing argument by any means, nor one which had any bearing on the absurd claim of the Pullman men that the company should arbitrate whether it should continue working at a still greater loss but yet an argument which affects the question of the general policy of that successful company. Pullman's great success has come from two things: his own ability and adroitness in taking advantage of every circumstance, and, next, the disjointed roads which make up our through routes. When several railways agreed to run cars over long distances in time-table connections, it was difficult for them also to agree to furnish the parlor- or sleeping-cars which long routes required and which the public demanded. It was much easier to contract with Pullman for the whole supply. Thus the use of these cars spread, particularly as their great cost (from $18,000 to $40,000 per car) deterred many weak roads from investing the capital required to build parlor- and sleeping-cars of their own. It was simpler to pay Pullman a handsome profit. But strong roads took advantage of Pullman's really weak position to make contracts which left but little profit. Thus the Pennsylvania railroad pays Pullman only the fares he may collect, while systems which were short of money—the Erie is an example—could secure Pullman cars only by paying him two cents per mile run, besides the fares and the usual agreement to keep the outside of the cars in repair. It is apparently inevitable that railways as they become large systems and have more money to invest in their own business, will either run their own parlor- and sleeping-cars to save the Pullman profit, or else demand such contracts from these palace-car companies as will yield them only a moderate dividend. At any rate the railway-managers just now feel a bit sore that they have had to bear the burden of a strike for a Pullman dispute.

THE mileage of new railway built in the first half of 1894 approximates 500 miles, or less than half that built in the corresponding six months of 1893. Of course the hard times will account for the decline in building, though there is a deeper cause also,—the lack of profitableness which railways are now experiencing partly through adverse legislation and partly through sympathy with a decline in profits affecting all industries. The former cause —business depression—it is hoped and believed will not keep our people bound down long; the latter is more far-reaching and will not be overcome in a day.

SOME statistics on the freight-car problem given by Mr. Wheatly before the car-accountants' convention, are interesting and instructive. During the year ending June 30, 1892, figures compiled from the interstate commission's reports show that private cars (cars not owned by the railroads) earned $14,269,405—and ran an average of seventy-five miles per day, for 70,000 cars. Each car thus earned on the average $200 per year or about 25 per cent. on its cost. Computations based upon the same reports give the average mileage of railway-cars at 23 miles per day, or but one-third of that made by private cars. One should not draw comparisons between these figures without remembering that private car companies have built their cars for trades which require rapid running and that if live-stock and refrigerator cars belonging to the railways were alone considered, their daily mileage would be much above twenty-three miles. Still it is a notorious fact that private cars are more carefully looked after and it is also said—how truthfully cannot now be vouched—that one reason why the railroads run them is that railroad officers are interested in the profits. Probably a more important reason for their hold upon the railways lies in the fact that mileage payment for private cars covers what is practically a rebate to the shipper. While we cannot eradicate rebates until we have some form of pooling, on a fair division of traffic or earnings between competing lines depends a great many reforms which would save the carriers considerable sums of money, while also doing away with that worst of all discriminations, the discrimination in transportation charges between one merchant and another.

THAT low average mileage of twenty-three miles a day for common freight-cars brings up a most serious problem in railway economics. If we estimate that a freight car costs $700—at 5 per cent., the interest charge yearly would be $35—then adding to this (say) $45 for depreciation (assuming that the life of a car is twelve to fifteen years) we have $80, that a freight-car must earn annually before profit begins. At twenty-three miles per day the yearly mileage of such a car is 8400 miles, which at ¾ of a cent amounts to $63. If, therefore, such a car were loaned out to other companies for the whole year, it would stand the owner in for a loss of $17. And certainly, though it may be run on its owner's road and carry first-class goods at high tariff rates, such a record shows bad economy. We have indeed touched a sore spot. We cannot divide the ton-mileage by a car's capacity and say that only so many cars are needed, for other things are to be considered. Traffic flows unequally on every road, as evidenced by the fact that throughout the United States empty cars constitute 29 per cent. of the whole car mileage. Again, cars must be sent where traffic is heaviest, which may come in turn at different places, necessitating the transfer of cars. Yet, when all is said, it is plain that we have perhaps a fourth more freight-cars in the United States than are necessary to do the business. The advantage of such a company as Pullman's is that he can mass his whole equipment where there is need for it, now in Florida and then in California. In short, if the railways are to manage their freight-cars properly they must have some sort of organization which shall control the equipment to the best advantage—a car clearing-house or something of the kind which might begin in some traffic association's territory.

ANOTHER paper of interest was that on demurrage, read by Mr. Simmons before the car-service managers. The practice of charging for delays to loaded cars is one for which strong arguments may be advanced. One reason for the small mileage of freight-cars just mentioned is, no doubt, their use for storage. Carriers are undoubtedly entitled to receive back their empty cars within a reasonable time. This principle is recognized in all the railway tariffs of Europe, which also provide a penalty for every day's delay to the property of the shipper and thus make the obligation reciprocal. But the time allowed for transit in Europe is about twice that taken on the average by American railways for the same distance. Hence the adoption of European methods would not suit our better service. The better way out of the dilemna is to admit the right of the carrier to demurrage after an unreasonable delay to the car; what is an unreasonable delay to be ascertained according to the circumstances, the kind of traffic carried, etc. But an element of injustice in any such scheme for demurrage was the practice of charging for delayed cars without giving credit for cars promptly unloaded. This led to the device explained in Mr. Simmons's paper, which has been successfully tried in Philadelphia, Cleveland, and elsewhere. This device is to calculate demurrage upon the plan of averaging the twenty-four hours. Under this plan both small and large shippers who can release certain of their cars quickly are invited to do so in order to offset such detentions as will inevitably happen to some cars during the month. If the average detention is within the prescribed limits, no demurrage charge is made. Any arrangement which is of mutual advantage to consignee and carrier and which avoids friction between them, is worthy of imitation, particularly at those places where friction about car detention is frequent and warm. The plan is also made the reason for a demurrage contract to be signed by both parties, thus removing misunderstandings.

In the Master Mechanics Convention there was an interesting discussion on the question of the cost of maintaining locomotives—whether greater for those built in the shops of the railways or for those bought by contract. Evidently there was not enough information to enable such a question to be answered satisfactorily, and it would be well, therefore, to postpone judgment until more is known. In the first place, engines differ from each other in style and capacity enough to vitiate any comparison unless just the same class of engines is taken in each case. In the same way, comparisons should not be made between freight- and passenger-engines since the service, and, therefore, the cost of repairs, is not the same. It is well known, too, that the speed of trains affects not only the cost of repairs but the cost of running a mile, so that comparisons between the engines of different railroads are of little value unless we know that we are comparing exactly the same conditions in each case.

Nevertheless, when all is said, it was the opinion of the committee that locomotive-building in the railroad-shops was cheaper to maintain, although all the figures quoted were not to the same effect. In one case six switching-engines built by contract cost 2.25 cents per mile for twenty-two months, while engines of the same class built by the railroad company cost 2.32 cents per mile for thirty-one months,—a difference, it will be observed, in favor of the contract-built engines. In another case, twelve railroad-built engines cost 3.59 cents for repairs against 3.62 cents per mile for contract-built locomotives,—a difference in favor of the former.

Coupled with this question is the further one whether the first cost of engines built in railroad-shops is more or less than that of engines built by contract. The committee expressed no opinion. The off-hand view of twenty-five roads was asked, of which eight replied that it was cheaper to build engines, three that there was no difference, and eight that it is not cheaper to build. The question, therefore, is left in abeyance, as nothing is proved by such figures. It is probably true that there does not exist any information of sufficient value to determine such questions. It is largely a matter of experience in each individual case. While it is undoubtedly true that engines, under certain conditions, may be built more economically in a railroad-shop, it is probably equally true as a general proposition that in the long run a railroad company will gain by having its engines built under contract by a reputable maker. It is coming more and more to be believed that the business of a railroad is transportation, pure and simple. That is their specialty—not the making of cars and engines. Companies usually now let out their construction by contract-work to men who make a business of building track or houses, and who have the necessary skilled workingmen, tools, and experience, as well as the material. It is not an extravagant prophecy to say that in the future the evolution of the railroad problem will lead the companies to confine their operations to the loading and hauling of passenger- and freight-cars, leaving everything else to be furnished by those who make a specialty of the matter in each case. As we know, the professions of law and medicine are cut up into specialties where experts work and devote their lives to one particular branch of their profession, and, while the great business of a railroad company can not be compared directly to medicine or law, yet it is probably true that the same principle will work itself out slowly, and that in time we shall see not only the furnishing of our cars and engines, but also the heavy repair-work done in separate establishments by those who will thus be enabled to do the building and repairing more cheaply and expeditiously.

THE Union Pacific railway bids fair, before we are done with it, to prove the most tangled problem in our railway finance. The government loan, which is a second mortgage on the main line, begins to come due in 1895. The first mortgage on the line, amounting to $33,000,000, matures at about the same time. The collateral trust notes must be treated this fall. Altogether the business questions are pressing ones. As is well known, the larger part of what is called the Union Pacific system is made up of branches which, in any case, are important railroad corporations in themselves. The bonds of all these branch railroads are in default and committees are being formed to demand for each class of bonds the largest possible share under any plan of reorganization. It is a well-known fact, brought out again lately in a petition of the receivers to the court, that the greater part of these branch roads do not of themselves earn their fixed charges. At first blush it would seem to be an easy matter to say let all such branch roads as do not earn their interest charges be cut off from the main line, but unfortunately for this view a careful series of compilations made during the time of the investigation by congress in 1887, and again lately, show that about one-third of the combined net earnings of the main line come from the carriage of traffic received from or delivered to the branch roads. If these branch roads were cut off, and if this interchange traffic were lost to the main line, that main line would only earn money enough to pay the first mortgage interest, leaving the government with its second mortgage practically worthless. It is evident, therefore, that the federal authorities, for their own sakes, to say nothing of the stockholders, can not afford to press upon the bankrupt company any such policy as would diminish the net earnings. On the other hand, as matters stand now, these branch roads are dependent upon the main line for an outlet. Some talk has been heard, indeed, of these various branch lines forming a new company by themselves and building another main line to connect them, and thus leaving the government to wrestle with the then worthless main line. While such a scheme is of course a possibility, it is hardly probable that the owners of the securities of these branch roads can be induced to take such concerted action as would place them in the most favorable possible position to demand their full mortgage rights. Besides that, Uncle Sam can not be treated like an ordinary creditor. All things considered, it would be part of wisdom for congress to fund the government debt on long time and at favorable rates of interest, leaving the rest of the creditors of both the main and branch lines to arrange their differences as best they can. The moral argument is also a strong one. The government loaned its credit to the Union Pacific at a time when no one supposed the building of such a line would be commercially profitable. The money was indeed invested by the federal government as a political measure. Certain men made large sums out of the Union Pacific, but it may be urged that they were entitled to a fortune for the pluck and energy which they displayed in the face of great obstacles. The fact that there was scandal connected with the building of this company does not affect the main argument. Under the best of circumstances a reorganization of this great system would require the greatest care and thought.

COMMENT & CRITICISM

A Defense of Henry George.

A REMARK made by Mr. William Nelson Black, in his article on "The Coxey Crusade and its Meaning" in the Magazine for June, seems to call for some comment. Let me say first, that I agree with the main conclusions of Mr. Black's article, but when he classes Mr. Henry George's proposition (to tax land, exclusive of improvements, at its annual rental value, abolishing all other taxes) with Populism and State Socialism he goes very wide of the mark. Moreover, when he says that "Sixty millions of peasantry in Russia with hardly intelligence enough to keep them from starvation, are living, as possibly their ancestors for a thousand years have lived, on lands held by substantially the same tenure advocated by Henry George in his 'Progress and Poverty,'" he makes a statement which has been made many times before and effectually answered.

I need not take up your valuable space with a detailed answer at this time, especially as it is sufficient to call attention to the fact that the Russian peasantry are regularly robbed, by taxation and otherwise, of all they can produce above the meanest and poorest living. On the contrary, Mr. George's plan would leave in the possession of producers *all* that they produce, and would require them to pay into the public treasury only the amount representing the advantage enjoyed by the possession of specific locations as compared with less favorable locations—a value created entirely by the community. In other words, all those who do useful labor of any kind, mental or physical, would be left in the full enjoyment of the results of that labor, and would be free to make such exchanges with other producers in this or any other part of the world as they may choose; each one being charged by government only for the bare annual site value of the particular portion of the earth's surface occupied by him. Does Mr. Black think that, under these conditions, men who work will be in a position resembling in any way that of the Russian peasantry?

Having made some examination of Mr. George's proposition, I am convinced that his plan would be very decidedly in the interest of all those who by mental or physical labor perform services that are of use to others, and that the only ones whose interests would be injured by it would be those who do not do this but who simply charge others for the privilege of doing it—and charge "all the traffic will bear." While I consider Mr. George's argument and logic unanswerable, I do not of course deny the right of others to dissent from them, but they should at least acquaint themselves with the subject before going into print regarding it.

J. K. MILLER.

Plainfield, N. J., June 22, 1894.

[We had intended to exclude any further controversy over Mr. George's proposals, for the reason that the subject was discussed at length in these pages about a year ago by Mr. Black and Mr. E. J. Shriver. For the purpose, however, of stating pointedly just why The Engineering Magazine is unalterably opposed to Mr. George's scheme, and why we regard Mr. Black's statement of the case as substantially correct, we have concluded to answer Mr. Miller's communication.

As the New York *Evening Post* observed about two years ago, there is no theoretical objection to the single tax as a means of raising the revenue necessary to government economically administered, but on the contrary there is much to be said in its favor. It is, however, an ideal system of taxation which has been before the world more or less prominently time out of mind, but because people everywhere greatly prefer systems of indirect taxation, it has rarely been adopted, and never enforced for any length of time.

But a single tax *limited to the necessities of government* is very radically different from what Mr. George proposes. Starting with the amplified declaration that private property in land is *robbery*, he deliberately proposes that all land-values shall be confiscated by the State. Far from qualification or reserve, he is frank, open, and even boastful in the declaration that each and every landholder is a robber, and that the government has not only the right, but owes it as a duty to the people, to confiscate the last farthing of land-values that can possibly be collected, after the complicated process of excluding improvements on the land has been gone through with. If Mr. Miller or any of his sympathizers desires specific authority for this representation, they are referred to the pages of "Progress and Poverty," and especially to page 364 of book VIII, where he says:

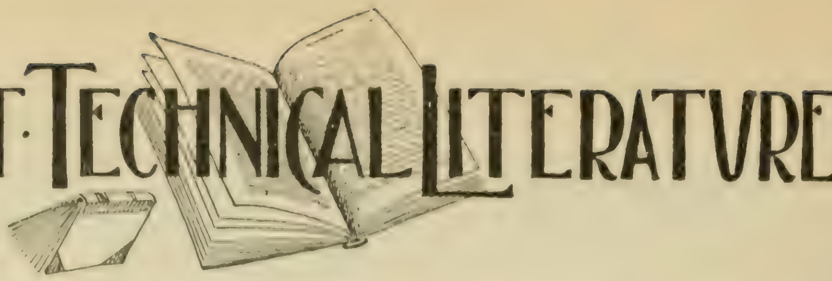
> We may safely leave them (the land-owners) the shell, if we take the kernel. *It is not necessary to confiscate land; it is only necessary to confiscate rent.*
>
> No owner of land need be dispossessed, and no restriction need be placed upon the amount of land any one could hold. For, rent being taken by the state in taxes, land, no matter in whose name it stood, or in what parcels it was held, would really be common property, and every member of the community would participate in the advantages of its ownership.

Now the confiscation of land-values after this fashion would, of course, aggregate an enormous revenue, far in excess of the needs of government. To make use of this great surplus, Mr. George comes forward with the socialistic proposal that the government shall buy and operate the railroads and the telegraph; that in the cities we shall not only have municipal electric, water, and gas-works, but that the local politicians shall also run free street-cars; that we shall have great free libraries, magnificent public baths, after the fashion of the Romans; and, somewhere in his writings, he advocates the altogether novel and picturesque idea that milk shall be distributed about the cities in underground pipes.

In short, Mr. George maintains that all right and title to land vests in the state, and not in the individual who occupies and uses it; and straightway he proposes a plan of asserting that right by means of confiscation through the single tax. The Czar likewise maintains that all right and title to the land of Russia is vested in the people, represented by himself, rather than in the individuals who occupy and use it; and while his plan for asserting that right differs somewhat in method from Mr. George's, in effect it asserts the identical principle as to land-tenure. Hence our approval of Mr. Black's statement of the case.

Fundamentally, such a system is in error because it ignores the obvious fact, proved by all history, that exclusive private property in land is not only the best but the most beneficent institution that civilization has yet adopted. But for the right of the individual to absolutely own and control that land which is necessary to his use, the civilization we enjoy to-day would not have been possible. There is, indeed, immediate and great need of some wise legislation to restrict the ownership of land which is neither occupied nor used. This is apparent to every thoughtful man who has looked into the subject; and the next step in the way of land legislation must be towards a return to the spirit and letter of the Homestead law, under which our vast public domain has been taken up, not by settlers, as was intended, but by speculators who now hold vast tracts of it out of use solely for speculative purposes. But legislation of this kind is very far from the wholesale confiscation proposed by Mr. George, and it is diametrically opposed to his fundamental tenet that property in land should vest in the state—in other words, that we should return to the primitive, socialistic organization of the Jews, Greeks, and Romans. —THE EDITOR.]

CURRENT TECHNICAL LITERATURE



THE MINERAL INDUSTRY: ITS STATISTICS, TECHNOLOGY, and Trade. Volume II. Edited by Richard P. Rothwell. New York: The Scientific Publishing Co. [Cloth. 8vo. xl-864 p. $5.]

FOR many years the *Engineering and Mining Journal* issued annually an extra supplement containing the statistics of the mineral industry for the preceding year. This supplement grew in time to be such an important feature of the *Journal* that it was decided not only to put it in book form, but to widen the scope of the statistical inquiry for the United States and, in addition, to give the statistics of foreign countries. When, early in 1893, the first volume thus compiled was issued, it was a surprise to even the most sanguine believers in the statistical and technical ability of the editor, Mr. Richard P. Rothwell. It was unheard of that an individual should have the courage and enterprise to carry out a work which involved even greater labor than the preparation of the government census on the same subjects, and, more than this, collecting data from every country in the world in addition to those from the United States, and also to present a series of articles on the existing condition of various mineral industries, each written by a recognized authority. It is, furthermore, the only work published in any language that gives the statistics of the mineral industry of the world.

The second volume of this work brings the statistics up to the close of 1893, and covers even a wider range in its technical articles, than did the preceding volume. It is impossible here to give such a review as each of the articles deserves. Among those from well-known authorities is one on aluminum, by Joseph W. Richards, which gives a comprehensive review of the improvements made in manufacturing this metal during 1893. A contribution on arsenic by William Thomas, secretary of the Mining Association and Institute of Cornwall, is a valuable addition to the literature on this subject. One of the most exhaustive and valuable articles is that by A. M. Gibson, on the history of alkali manufacture in Great Britain. Another article, covering as wide a scope, is that upon clay, by Heinrich Ries, which gives a mass of information not available from any other source. Coal is fully treated by H. S. Fleming and some instructive diagrams of the world's production and consumption of fuel are given. Upon copper there are two articles which treat the metallurgy of that metal up to present practice,—one by the well-known authority, Dr. Edward D. Peters, Jr., and the other, upon American practice in electrolytic copper-refining, by Titus Ulké. This latter article is the first which has yet treated this important subject exhaustively, and is therefore worthy of particular note. The article on gold and silver betrays Mr. Rothwell's careful supervision in its accuracy and comprehensiveness. Iron and steel, with the advances made in their metallurgy during 1893 are carefully treated. Two valuable papers by W. R. Ingalls treat, one on the distribution and production of lead, and the other on the present condition of the zinc industry in Europe. Another valuable contribution is that on petroleum, showing the condition of this industry throughout the world and concise information as to the processes of refining and preparing it for market. Robert H. Richards, writing on the progress in ore-dressing in 1893, gives a brief review of the various important improvements made in this branch of metallurgy during the year. No mention can be made of a large number of other articles of no less interest and value.

Even the briefest review of the work would be incomplete, however, without reference to the astonishingly complete set of statistical figures as to the production and consumption of various minerals in the United States and other countries. Their general arrangement, which is better than that in Volume I, coupled with an unusually complete index, permits reference at a moment's notice. And a priceless feature of the work consists in the fact that when reference is made to these statistics, one can rely upon their accuracy. Such information is almost invariably published by national or state governments, and the work is done by men in whom the prime essential of fitness is that ability and alertness at political wire-pulling which will secure appointment. The consequence is that governmental statistics are, with very rare exceptions, notoriously inaccurate and they are invariably months or years behind with the publication of the information desired. In this case, however, the only possible hope of reward to either publishers or editor must come throngh the reputation for accuracy and promptness which the book itself makes. For this reason we feel warranted in the statement that no other statistical work of equal magnitude has ever before been produced, which rightly commands and fully deserves the commendation and confidence of so wide a circle of trained readers and skilled statisticians. It indeed ranks preëminent as the source of such information in its particular field; and by virtue of the high reputation which it has already attained, and the evidences of profit which its repetition and rapid expansion indicate, we regard it as the forerunner of a radical and needed change in the direction of taking such important work out of the hands of goverment, to the end that the field may be open for the free competition of those whose actual accomplishments distinguish them as the ones best equipped to conduct such enterprises.

COAL DEPOSITS OF IOWA. VOLUME II OF THE REPORTS of the Iowa Geological Survey. By Charles Rollin Keyes. Des Moines: Published by the Survey. [Cloth. 4to. 536 p. with maps.]

COAL is by far the most important item of mineral wealth in Iowa. In that state the coal-measures have an area of over 20,000 square miles, or counting the workable area at one-half, the coal-bearing territory equals in area that of Great Britain, is three times as great as that of Germany, and four times that of France and Belgium. The coal does not occur in very heavy beds, but for the most part lies comparatively near the surface and is easily and cheaply mined. This report is the first authoritative account of the Iowa coal-deposits, and it is intended to be followed by other reports in more detail, as systematic exploration progresses. It is prepared with a view to popular use, and will be of much value to those engaged in the local coal industry, as well as to outside investors seeking reliable information on the subject. In an introductory chapter stress is laid on the vast economic importance of coal supplies, and on Iowa's favored position in this respect. Chapter II discusses the origin and mode of formation of coal and the associated beds. Then follows a description of the whole carboniferous basin of the Mississippi valley (in which, by the way, there are some slight inaccuracies as to the western plains region), and of the general geology of the coal territory. A chapter is devoted to the lithology, and another to the stratigraphy, of the coal-measures. Succeeding chapters treat of the coal-beds opened in the several counties of the state, and the accompanying sections are very interesting. The question of waste in coal-mining is considered in some detail under the heads of waste due to methods of mining, in removal of coal, and in fine coal. The volume concludes with an exhibit of the extent of the local coal interests, growth in production (from 48,263 tons in 1859 to 4,047,479 tons in 1892), number of mines and value of product, mining localities, present territory supplied, and markets. The report is well gotten up and handsomely illustrated.

TELEPHONE LINES AND THEIR PROPERTIES. BY WILLIAM J. Hopkins, Professor of Physics in Drexel Institute, Philadelphia; New Edition Revised and Enlarged. New York: Longmans, Green & Co. [Cloth. 12mo. xvi-272 p. $1.50.]

THE literature on telephony in America is so scant that no one interested in the subject can fail to accord to any work bearing on telephone practice a hearty welcome—even to a work containing so many defects as this does. Even though the author partially disarms criticism by his *naif* confession in the preface that "the subject of exchanges has been taken up principally to round out the scope of the book," one can scarcely excuse the presence of much matter that gives continual evidence of a lack of practical acquaintance with the subject. The defects of the book are almost entirely due to this lack of practical knowledge, which in many places leads to extremely superficial remarks on matters of importance, in others to giving obsolete information an air of modernity, and in still others to absolute inaccuracies. The peculiar conditions under which the telephone industry in this country flourishes militate against the production of works on telephony by those who alone have the requisite knowledge and experience, so that a text-book on the subject for American readers is not to be looked for in the near future. So we must put up with what we can get. From the reviewer's point of view, however, Professor Hopkins has made a decided mistake in "rounding out the scope" of his little work with matter that is certainly not new and in cases no longer true. Where he writes from his own knowledge and experience he is admirable and that portion of the book to which the title truly applies should be studied by every young telephone engineer.

Chapters I, II, and III, on "city lines," "underground work," and "long-distance lines," give a fair summary of the practice they refer to; by far the best of the three is the chapter on the building of long-distance lines. The remarks on cables are sadly incomplete and those on distribution of lines are sadly out of date. Chapters IV, V, VI, and VII deal with "wire," "insulators," "exchanges" and "switchboards." Those on "wire" and "insulators" are good and practical; those on "exchanges" and "switchboards" might better have been omitted altogether. Chapter VIII, on "the propagation of energy" is inserted because the author's intention was to make the book "useful to the practical man as well as that it should serve as a basis for a lecture course to students." The very title of the chapter would strike terror into the soul of the "practical" man, as we know him, and students would probably go for such information to sources where it is more fully dealt with. Chapters IX to XIII, dealing with "the telephone current," "measurement," "properties of city lines," "interference from outside sources" and "properties of metallic circuits," are by far the best part of the book. They contain a clear exposition of the properties of telephone lines, and much special information that is to be found in no other book; here the author is evidently in his own element and no telephone engineer can fail to follow him with profit. Chapter XIV (and last), on "cables," is open to criticism on the score of superficial and out-of-date information. The book closes with two appendices: one an interesting little essay on (electrical) "oscillations," the other a reprint of a paper on telephone induction read in 1891, before the American Institute of Electrical Engineers, by Mr. J. J. Carty, to whom Professor Hopkins acknowledges his indebtedness for a fair proportion of the information in the body of the book.

The present edition is styled "revised and enlarged." The next edition should be revised and reduced. The matter here criticised as obsolete and superficial should be omitted entirely, and the book would be greatly the better for it; to the telephone man it would be more readable, to the student it would be more valuable. By such a revision and by the editing of sundry matters of detail by a practical telephonist Professor Hopkins would secure a book which would bear out its title and fulfil its purpose far better than the present volume. From a literary and mechanical point of view the book is an ornament to technical literature.

HERBERT LAWS WEBB.

AMERICAN STREET RAILWAY INVESTMENTS. (ANNUAL Supplement to *The Street Railway Journal*) For Bankers, Investors and Street Railway Companies. New York: The Street Railway Publishing Co. [Cloth. 4to. 216 p. $5.]

NOTHING that could be asked for in a reference-book for the use of investors or intending investors in street-railway securities has been omitted in the compilation of the work above described. The utmost pains seems to have been taken in compiling the statistics of capitalization, the physical condition and the details of operation of all the street railways in the United States. This field, though but recently developed, is a most promising one for judicious investors, and this volume is the first comprehensive guide to those who are interested in this field. The book will be found none the less valuable to engineers who are engaged in street-railway construction or are contemplating such work.

THE OFFICIAL RAILWAY LIST: A COMPLETE DIRECTORY of [all officials of] Railways in North America, and Handbook of Useful Information for Railway-Men. Chicago: Railway Purchasing Agent Co. [Cloth. 16mo. 340 p. $2.]

A WORK of great completeness, and bearing evidence of trustworthiness, which, while not technical in character, deserves mention here because of the interest which it will possess for all readers of the Magazine who have any sort of business relations with railway companies. This is the thirteenth annual edition.

THE SOIL IN RELATION TO HEALTH. By H. A. MIERS. M. A., F. G. S., F. C. S.; and R. Crosskey, M. A., D. P. H London: Macmillan & Co. [Cloth. vii-135 p., with diagrams.]

THIS little book is a model of its kind. As set forth by its authors it is not only for medical men, but for laymen as well. It is meant to impart enough knowledge of the earth—its formation, surface, water-supply, germs, and the diseases they produce which are peculiar to certain localities, its relation to the air both above and in the soil, etc.,—to be of practical value to the individual in deciding (1) what community he shall seek as a home, and (2) in what part of that community he shall locate his house. Chapter I treats of "rocks and soils," the two great divisions of rocks (the igneous and the aqueous) being described. What is of more importance is that the character of the soils formed by the disintegration of these several rocks is defined; so that, knowing the rock formation of any district, one can form some idea of the nature of the soil there. In chapter II, on "humus and micro-organisms," the formation of the surface soil, the micro-organisms therein contained, and the diseases they cause, are discussed. Stress is laid upon the fact that the surface soil is composed, not only of inorganic matter, but of the products of decomposition of animal and vegetable matter. The soil may contain, therefore, the germs producing malaria, diphtheria, typhoid fever, and other dangerous diseases, so that it becomes of first importance to know what soils favor the growth of the micro-organisms that produce these diseases. The "distribution of water in the soil" is next treated, with reference to the carrying of infection by means of the water-supply. Next the book gives "the constituents of water" from the different rock formations and different soils, and their significance. The chapter on "the soil in relation to air" treats both of the air above the surface and that in the surface of the ground, and their relation, and shows how soils of different nature may affect the climate and indirectly the healthfulness of any region. Finally a chapter is devoted to "the geological distribution of disease." Taken altogether, as a "small book on the principles of geology in so far as they concern sanitary science" this volume cannot be surpassed. For the home-seeker it contains a great number of practical facts in a very small space.

A. E. DAVIS, M. D.

NEW BOOKS OF THE MONTH.

Bowley, A. L.=A Short Account of England's Foreign Trade in the Nineteenth Century, its Economic and Social Results, with Statistical Diagrams. (Social Science Series.) New York: Scribner. [Cloth. 12mo. 8–152 p. $1.]

Britten, F. J.=Former Clock- and Watch-makers and their Work. New York: Spon & Chamberlain. [Cloth. 12mo. 397 p. $2.]

Brown, G. P.=Drainage Channel and Waterway; a History of the Effort to Secure an Effective and Harmless Method for the Disposal of the Sewage of the City of Chicago, and to Create a Navigable Channel between Lake Michigan and the Mississippi. Illustrated. Chicago: R. R. Donnelley & Sons Co. [Cloth. 8vo. 480 p.]

Conder, Josiah.=Landscape Gardening in Japan. New York: Scribner's, *importers*. [Cloth. 4to. 2 vols. 61 p., 40 pl. $25, *net.*]

Graham, Maurice.=Practical Hints on the Construction and Working of Regenerator Furnaces. New York: Spon & Chamberlain. [Leather. 16mo. 131 p. $1.25.]

Iles, George.=A Class in Geometry: Lessons in Observation and Experiment. New York and Chicago: E. L. Kellogg & Co. [Leather. 12mo. 46 p. 10 cents.]

Kingsley, C.=Town Geology. New York: Macmillan. [Cloth. 16mo. 239 p. 50 cents.]

McCain, C. C.=Compendium of Transportation Theories. A compilation of essays upon transportation subjects by eminent experts. Publication of series under direction of C. C. McCain. Washington: Kensington Publishing Co. [Cloth. 8vo. 3-295 p. $2.]

McKinney, W. M., *editor.* = American and English Railroad Cases. A collection of all the railroad cases in the courts of last resort in America and England. Vol. LIV. Northport, N. Y.: E. Thompson Co. [Sheep. 8vo. 735 p. $4.50.]

Macvane, S. M.=The Austrian Theory of Value. Philadelphia: American Academy of Political and Social Science. [Paper. 8vo. 41 p. 25 cents.]

Marshall, H. Rutgers.=Pain, Pleasure, and Æsthetics. An essay concerning the psychology of pain and pleasure, with special reference to æsthetics. New York: Macmillan. [Cloth. 8vo. 364 p. $3, net.]

Miller, J. A.=An Outline of Qualitative Analysis. A laboratory manual. New York: Scientific Publishing Co. [Cloth. 12mo. 58 p. $1.50.]

Newcomb, Simon.=The Problem of Economic Education. Boston: G. H. Ellis. [Paper. 8vo. 2-27 p. 25 cents.]

New Republic (The).=A scheme to abolish poverty. The Anti-poverty society of the American plan; social democracy. New York: The New Era Publishing Co. [Paper. 24mo. 2-62 p. 25 cents.]

Palgrave, R. H. Inglis.=Dictionary of Political Economy. Containing articles on the main subjects usually dealt with by economic writers; with explanations of legal and business terms, which may be found in their works, and short notices of English, American, and foreign economists, and their chief contributions to economic literature. Vol. I. New York: Macmillan. [8vo. 800 p. $6.50, net.]

Peddie, William.=A Manual of Physics for Higher-Grade Students. New York: Putnam. [Cloth. 12mo. 514 p. $2.50.]

NEW TRADE CATALOGUES.

Any of these catalogues free on application to the manufacturers.

A. Falkenau, Philadelphia.=Superior 14-in. Lathes, Grinding Machinery, Hydraulic Machinery, Special Machinery. 20 p.

Albert & J. M. Anderson, Boston.=Electric Railway, Light, and Power Specialties and Material. 38 p.

Johnson Engineering and Foundry Company, New York.=Hydrants, Valves, Special Castings for Water, Gas and Steam. 16 p.

J. T. Connelly, Milton, Pa.=Railway, Steamship and Stationary Engine Appliances. 32 p. [Improved mechanical devices, new design of locomotive boiler, etc.]

Roberts Manufacturing Company, Pittsburgh, Pa.=Patent Detachable Steel Link Belting, Sprocket Wheels and Shafting. 32 p.

The Sterling Company, Chicago.=The Sterling Water Tube Safety Boiler. 80 p. [An artistic publication descriptive of the Sterling Water Tube Boiler, containing also in compact and convenient form, items, tables and facts of general interest to those connected with the generation of steam.]

Sebastian Lathe Company, Cincinnati.=Descriptive Catalogue Machinery, Tools and Supplies. 47 p.

Dodge Manufacturing Company, Mishawaka, Ind.=General Catalogue Hangers, Pillows, Blocks, Friction Clutch Pulleys, etc. 70 p.

Bass Foundry and Machine Works, Fort Wayne, Ind.=Improved Bass Corliss Engines. 79 p.

The Chapman Valve Manufacturing Company, Indian Orchard, Mass.=Gate Valves and Fire Hydrants. 146 p. [Descriptive price-list of valves. Also contains articles on steam, electricity and refrigeration by well-known authorities, together with an engineering appendix containing valuable rules, tables, etc., compiled from standard authorities.]

Siemens & Halske Electric Company of America, Chicago.=General Catalogue. 160 p. [An exhaustive publication describing various electrical machinery and appliances manufactured, with directions for care of dynamos.]

Central Electric Company, Chicago.=Illustrated General Catalogue. 525 p. [A handsome and well-gotten up publication.]

Builders Iron Foundry, Providence, R. I.= Our Share in Coast Defence. Part II. 55 p. [Brief description of the manufacture of cast-iron bodies for 12-inch breech-loading mortars. Of interest to mechanical engineers and those following advanced foundry and machine shop practice.]

Hogan Boiler Company, Middletown, N. Y.= Quarterly Boiler Review. 18 p. [Discussion of circulation of water in steam boilers.]

The Huyett & Smith Manufacturing Company, Detroit, Mich.=General Illustrated Catalogue, No. 28. 125 p. [General Description of the Huyett & Smith Hot-Blast Furnaces, together with suggestions for heating and ventilation.]

W. & L. E. Gurley, Troy, N. Y.="As in a Glass." [A handsome souvenir publication descriptive of the civil engineers' and surveyors' instruments made.]

F. C. Austin Manufacturing Company, Chicago.=Municipal Machinery Catalogue. 32 p. [Gives full descriptions, with illustrations of street sweepers, sprinklers, rock crushers, etc., of interest to those concerned in care or construction of paved roads or streets.]

THE

ENGINEERING MAGAZINE

VOL. VII. SEPTEMBER, 1894. No. 6.

COMMERCIAL ASPECTS OF THE JAPAN-CHINA WAR.

By Ter. M. Uyeno.

IT is more than probable that the war now in progress between Japan and China, the two largest empires of Asia, will be of long duration and of serious consequences. It may last for years. It may lead to a general complication with European nations,—particularly those which have large commercial or territorial interests in the east, and especially England and Russia. Russia wants a foothold in Corea in order to establish her supremacy in the Pacific. The present headquarters of Russia in the Pacific coast are at Vladivostock, which, while possessing a magnificent harbor, is altogether too cold in winter; during several months of the year no ships can move in or out on account of its ice-bound condition. Russia wants Port Lazareff on the eastern coast of Corea to make it the terminus of her great Siberian railway, as well as the headquarters of her military and naval forces on the Pacific coast. But England will not, under any circumstances, allow Russia to assert her power in that part of the world without a bitter contest, for in that case the British supremacy in the east would be a thing of the past.

The United States, under a wide construction of the "Monroe doctrine," will not allow itself to be led into an entanglement in this instance. What concerns the American people most, therefore, is not the political effect of the hostilities which are raging between Japan and China,—whose object is, on either side, to destroy lives and property of the enemy,—but the effect which this war may have upon the "peaceful commercial warfare" which is carried on for mutual benefit and advantage by the United States with both Japan and China.

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Let us examine the quantity and the quality of the trade now done between the United States and the two belligerent nations. The official report of the bureau of statistics of the treasury department at Washington for the fiscal year 1892–93 gives the following figures:

IMPORTS FROM JAPAN—FISCAL YEAR 1892–93.

Camphor, crude	$ 302,349
Sulphur, crude	133,455
Chemicals, drugs, and dyes	58,032
Hats, bonnets and hoods, material for	119,286
Paper stock, crude	113,993
Silk, unmanufactured, raw and waste	14,791,633
Tea	5,699,582
Coal, bituminous	8,544
Earthen, stone, and china ware	407,109
Flax, hemp, jute, etc., manufactures of	64,408
Metal compositions and manufactures of	92,848
Paper and manufactures of	310,986
Rice and rice meal	324,412
Silk, manufactures of	3,347,834
Wood, manufactures of	140,974
All other articles	1,538,775
Total merchandise	$27,454,220
Specie—Gold	89,274
Silver	2,407
Total merchandise and specie	$27,545,901

EXPORTS TO JAPAN—FISCAL YEAR 1892–93.

Books, maps, engravings, etc	$ 16,790
Breadstuffs—Wheat flour	193,945
Chemicals, drugs, dyes, and medicines	20,514
Clocks and watches and parts of	114,694
Cotton cloth	9,084
Fruits, preserved	11,813
Iron and steel and manufactures of	88,314
Machinery	104,954
Leather—Sole	147,071
Oils—Mineral refined	1,724,972
Provisions, comprising meat and dairy products	68,050
Stationery, except paper	14,174
Tobacco, manufactures of	232,662
Wood, manufactures of	63,268
All other articles	379,406
Total domestic merchandise	$3,189,711
Foreign merchandise	5,783
Specie—Silver	4,150,980
Total merchandise and specie	$ 7,346,474

IMPORTS FROM CHINA—FISCAL YEAR 1892-93.

Chemicals, drugs, and dyes	$ 136,455
Coffee	262,236
Farinaceous substances, etc.	13,510
Hats, bonnets, and hoods, materials for	405,329
Hides and skins, other than fur skins	464,149
Mattings for floors, of round or split straw	755,679
Silk, unmanufactured, raw and waste	5,470,380
Spices, unground	118,874
Tea	7,413,984
Opium prepared for smoking, etc.	473,517
Cotton, manufactures of	41,272
Earthen, stone, and china ware	16,242
Fish	30,502
Fruits, preserved	19,727
Furs, and manufactures of	512,382
Leather, and manufactures of	333,010
Paper and manufactures of	24,800
Provisions, meat products	33,384
Rice	528,408
Seeds	6,841
Silk, manufactures of	338,659
Spirits, distilled	19,778
Tobacco, manufactures of	38,666
Vegetables	65,702
Wood, manufactures of	54,926
Wools and manufactures of	25,565
Wools, unmanufactured	1,812,250
All other articles	1,220,380
Total merchandise	$20,636,535
Specie—Gold	129,360
Total merchandise and specie	$20,765,895

EXPORTS TO CHINA—FISCAL YEAR 1892-93.

Breadstuffs—Wheat-flour	$ 66,699
Clocks and watches, and parts of	16,578
Cotton cloths	1,638,657
Iron and steel and manufactures of	52,431
Leather and manufactures of	7,542
Oil, mineral, refined	1,809,437
Provisions, comprising meat and dairy products	25,942
Tobacco, manufactures of	76,749
Wood, boards, deals, and planks	80,718
All other articles	125,694
Total merchandise	$3,900,457
Specie—Silver	50,000
Total merchandise and specie	$3,950,457

It thus appears that the commerce of the United States with China and Japan is one-sided. We buy largely from both countries, but sell little to either. They can buy cheaper from Europe than from us, while we are compelled to buy from them by the fact that most of the commodities are procurable only from those countries. Some classes of goods which are obtainable elsewhere can be sold to us for less money by China or Japan than by other countries. The most important articles imported from Japan are silk (raw and manufactured) and tea, which amount to more than 80 per cent. of the total imports from that country. Our shipment of petroleum heads the list, and this is the only article of considerable value going in that direction. Our export to China amounts to a little less than $4,000,000,—with kerosene and cotton cloths as the principal commodities,—but she supplies us with goods worth over $20,000,000, tea and silk being the chief articles, as in the case of Japan.

Now as to the quality of goods imported from Japan and China. The principal articles are raw silk and tea, which cannot be produced so cheaply in the United States. Tea is peculiar to those countries, for climatic reasons, while the quality of silk goods imported from Japan is such that American looms cannot duplicate them.

The volume and character of the imports of China and Japan from the United States show the higher state of civilization and greater development of manufacturing in Japan as compared with China. China, having a population ten times larger than her neighbor, buys of us very little more than the latter, while falling far short with respect to exports. The imports of Japan are larger in each item, except in the case of kerosene and cotton cloth. With regard to cotton cloth the cause is plain. Japan has of late years built numerous spinning factories, and not only can supply its own wants, but is supplying China with cotton yarns. With China, books, maps, engravings, stationery, musical instruments, etc., are so insignificant that the statistical bureau has seen fit to throw them together in an unnamed item, while in the case of Japan all these have been itemized.

Though one-sided, the commerce of the United States with Japan and China is yet extensive and important. If the war should become extensive and prolonged this vast commercial interest undoubtedly will be disturbed in no small degree. Should the belligerent powers see fit to blockade the ports of each other the supply of certain commodities will be cut off for the time being. Opinions are divided as to the possibilities of European interference in case of blockade of treaty ports. I am inclined to think that both Japan and China have their own independent rights and responsibilities to do what they like in times of war, and it is only right for other powers to observe strict neutrality. But if outsiders should want to carry on their trade with either of the belligerents, when the other intends to blockade the ports, it would simply mean aiding and abetting warfare, and therefore they would be considered as violating the terms of neutrality. Reserving this right to herself, the Japanese government has signified her intention of not blockading certain ports in China until the necessity arises. On the other hand, China has not the requisite naval strength to send out boats to blockade Japanese ports. Therefore, for the present at least, there is little apprehension to be felt as to a blockade of the treaty ports of either country.

There are other causes which should be taken into consideration, however. In times of war, men belonging to the industrial classes may be recruited into active service, while others will be required to work on munitions, ammunition, and other military and naval stores rather than in their vocations of peaceful industry. The general public will feel greatly interested and concerned and naturally their attention will be called away from business to matters of war. Such will be the case with the Japanese, I am positively certain. The Japanese people, as a class, are most loyal and patriotic, and when the honor and dignity of the country are at stake they must know the news of the day before anything else. Every minute taken away from the working time of each of those silk-reeling girls, silk-weaving hands, and tea-picking girls must tell in the end upon the production.

Now the American exports to Japan and China, as already shown, are comparatively small, but this might be interfered with by the war, as well as our import trade from those countries. Nations at war cannot afford expenditures for anything but necessaries, and these necessaries in times of war are arms and ammunition. These latter are what are called contrabands of war and therefore liable to seizure by the belligerent governments. All the mail-steamers plying between the Pacific coast of America and Chinese ports have to call at Yokohama on their way to China, and each of them will be subjected there to close inspection by the Japanese government. Therefore, exports from this country to China will be much more seriously disturbed than those to Japan, as China cannot intercept incoming steamers to Yokohama.

The silver element in the commerce of this country with China and Japan is one that must not be lost sight of. Conflicting opinions prevail as to the effect of the present war upon the price of silver. Some say that it will go lower, because the two hostile countries will have to pay in silver for what they buy instead of with commodities, as in times of peace, and that the London market, therefore, will be over-supplied with silver, with the result of causing its price to fall still lower. I am inclined to think that the reverse will be the case. The combatant nations will need silver more than they require goods, and they need more money than their available supply, and therefore they will draw silver from London by one means or another, and thus the London supply of silver will be decreased and the price, in consequence, increased. Thus far no effect has been shown upon the white metal, the price of which has of late been remarkably steady.

The most annoying effect of the war upon the commercial world up to date is the delay in the transmission of cable messages between America and the east. It is frequently the case with such commodities as silk and tea that offers are kept open only for a short time—say three or four days—and no doubt several important transactions have already fallen through on account of the delays of cablegrams.

The present emergency affords additional proof that a Pacific cable line between San Francisco and Japan, via Honolulu, would be of the greatest importance to the commercial, political, and naval interests of the United States. The war telegrams now coming from various cities in Japan and China not only are delayed in transmission, but the news is far less complete than should be the case during the progress of a great war in these days of electric cables. One cause of the present unsatisfactory news service is due without doubt to the prohibition by the Chinese government of all private messages over their lines ; besides, the Siberian land-lines are often liable to interruptions. But with a direct Pacific cable we ought to be in possession of all the news within a few hours of occurrence, and that in an accurate form. While not an expert in telegraphic matters, I cannot help thinking that the ever-increasing commercial and political interests in common of the United States, Hawaiian republic, Japan, China, and other Asiatic countries would be sufficiently important to support a direct cable service. When the present war is over, the commercial importance of the east to the United States will be vastly augmented.

The direct cause of the present war was the rebellion in Corea of a certain faction of malcontents. The rebels proving too much for the government of the peninsular kingdom, the king asked for aid from China, whose government forthwith landed a large force of troops in Corea. Thereupon Japan was compelled to send her troops to the peninsula for the purpose of protecting the lives and property of the Japanese subjects domiciled there. According to a treaty between Japan and China, each country, upon giving due notice to the other, has the right to land troops in Corea. The Japanese have large commercial interests in Corea,—larger, in fact, than all other treaty powers combined.

It must be understood that there have been many disturbances in Corea and in every instance the aim and purpose of the mobs have been against foreign intercourse. At times the rioters have attacked the Christian missionaries, and, again, the mobs have aimed their blows at the Japanese, including the legation of that country in Seoul. During the last twenty-five years Japan has had a series of provocations sufficiently strong for bombarding Seoul, taking the king prisoner, and making the whole peninsula a Japanese territory.

The great civil war in Japan seventeen years ago was waged over the principle of Corean invasion, and it cost a great deal more than a Corean invasion would have cost. Some of the ablest and most patriotic Japanese generals and statesmen were killed, in addition to an enormous waste of money. But, from a love of peace and civilization, Japan has always shown leniency towards Corea, and the larger part of the originally small indemnities levied against Corea remains unpaid.

On the other hand, it seems certain that China is constantly aiding and abetting the barbarities of the Coreans towards Japanese and other foreign residents. In the recent case of the murder in Shanghai of Kim ok Kun there was very wide room for suspicion of Chinese being behind the screen. Kim ok Kun, a native of Corea, had been a political refugee for years in Japan, protected by the Japanese government. Kim ok Kun was induced by a Corean to go to China for the purpose of interviewing Li Hung Chang, and on his arrival in Shanghai he was stabbed by the supposed friend and then the corpse was placed on board a Chinese man-of-war and sent to Corea, where it was dismembered and exposed to public view in various parts of the country. It may be added that the assassin was discovered to be armed with the authority from the king himself, and on his return home he was promoted to high official rank for his criminal act.

China has been asserting suzerainty over Corea, in spite of the independence of the latter recognized by several civilized nations, including the United States. These countries have treaties of amity and commerce with the kingdom of Corea, and diplomatic representatives are exchanged, as between entirely independent countries. In the present instance, notwithstanding the treaty stipulations, China peremptorily and impudently requested Japan to withdraw her troops from Corea. Japan politely declined, but instead submitted to China propositions to coöperate in introducing reforms in the administration of the Corean government so as to prevent a recurrence of internal commotions which endangered the lives and property of alien residents in the peninsula, including Japanese as well as Chinese. China refused to listen and immediately began warlike preparations. On July 23, at the instigation of the Chinese resident minister at the Corean capital, a combined army of Coreans and Chinese attacked the Japanese garrison at Seoul and were badly defeated, the Japanese taking the king captive. After several engagements the emperor of Japan on August 1 made a formal declaration of war against China, and the diplomatic representatives were withdrawn from their respective courts. The next day the Chinese emperor issued a characteristic reply. While the fighting is going on between Japan and China the Corean king has accepted the Japanese propositions and authorized his father, Dai In Kun, to proceed with reforms in the administration, with the assistance of the Japanese minister in Seoul.

In fighting strength, on both land and sea, the belligerent countries are not well matched. Homogeneous, united, and patriotic, the Japanese army, drilled to perfection under the best European methods and with weapons of the latest inventions, must, as a matter of course, win victory after victory over the dissimilar, disorganized, timid crowd of Chinese troops, some of whom are said to carry old-fashioned bows and arrows. It must be admitted that China can reënforce her army to ten times as great a number as her combatant; but if numerical strength is the only element required for success in war, all Europe combined would be unable to defeat the Chinese. Japan can, if necessary, send out 150,000 troops, reserving a sufficiently strong force at home to protect herself, and she has enough stores to sustain three years of foreign war.

China has a navy of some forty-seven vessels, whose tonnage is 67,147 tons, as against Japan's thirty-five vessels of 65,526 tons. Many of the Chinese vessels are small unserviceable boats, while some of Japan's are among the most formidable war-ships afloat. China has already lost eight of her best vessels and her northern squadron is now of very little service. Under these circumstances it seems only right that Japan should win in a series of short, sharp, and decisive victories, and bring the Chinese to reason on a proposition for settling differences peacefully. However, the latter are characteristically obstinate and stubborn and the war may drag on indefinitely.

But sooner or later the war must come to an end, when China will find out what modern art and science can do in warfare. The defeat will open the eyes of the Chinese and will lead them to the path of progress, and the result will be a propagation of modern civilization into a land which has never yet been able to avail itself of the advantages of it. We in America shall then see a vast increase of trade and commerce with China and other Asiatic countries.

NIKOLA TESLA AND HIS WORK.*

By Nelson W. Perry, E. M.

IT is not often that it is in good taste to estimate the character of a man while he is living, or safe to weigh his works or to estimate their proper place in any science while it is still in an embryotic state. There are exceptions, however, as in the case of political and other celebrities who, by reason of their eminence, have become in a sense public characters, or whose work has already revolutionized the science in the interest of which it has been undertaken. Under both of these exceptions it seems altogether proper to speak of Mr. Nikola Tesla, for if a man by taking two continents by storm may be called a public character in the sense in which the expression is here used, Mr. Tesla is one, and if the discovery of a new system such as the rotary magnetic field which in a few years has largely revolutionized our methods of conversion of electrical into mechanical energy, and which has formed the basis of the greatest attempt at power-transmission ever made, partakes of the nature of a revolution of the science, then for this reason may Mr. Tesla's work be reviewed with propriety while their author is still in the flesh.

Mr. Tesla was born in 1857, and therefore is still quite a young man, but he has crowded within his thirty-seven years of life an experience that would be considered ripe for any one of a dozen other men if it were divided equally among them. While foreign-born (at Smiljan-Lika on the borderland of Austro-Hungary), he is an American by adoption. Though proud of his adopted country he is not so intensely American as some foreigners become who adopt this country as their home.

The one discovery of Mr. Tesla which among practical men stands out most prominently to-day, because of the practical results already obtained, is his discovery of what is generally known as the rotating magnetic field. The alternating current, as the name would imply, means a current which changes its direction periodically. It possesses many characteristics peculiar to itself. The distinct advantage of an alternating or undulating current over a steady current such as heretofore used in arc-lighting is, that one is able to dispense with a large resistance in the dynamos and lamps which are necessary in order to obtain a steady light. This produces a greater economy in the circuit all along. For transmission purposes its advantages so far outweigh its disadvantages as to make it the method *par excellence*. Alternating-current motors enable us to obtain results which are not possible with motors heretofore used, namely: the motor may be made to run in perfect synchronism with the generators. In the ordinary motors the speed as is known falls below this increase, but not so in the motors just mentioned. But if one desires it is possible also to exactly imitate an ordinary direct-current motor and produce a machine which will have a great effort on the start.

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*In the publisher's announcement, some months ago, of a series of papers on "Electrical Science up to Date," was included the promise of a paper in this volume of THE ENGINEERING MAGAZINE, by Mr. Nikola Tesla, on "Electric-Lighting Without Heat." Only the unfortunate condition of the health of Mr. Tesla has postponed his compliance with his engagement in this connection. In order to keep faith, so far as possible, with the readers of the Magazine, there is presented herewith a paper by an electrical engineer who enjoys the acquaintance of Mr. Tesla, reviewing the discoveries of the latter gentleman which it was hoped that the inventor himself would be able to describe for us. The paper thus prepared has received the approval of Mr. Tesla, who, indeed, furnished personally some of the suggestions upon which it is based.—THE EDITOR.

Mr. Tesla conceived an idea which has entirely overcome the shortcomings of the alternating current as applied to motors. Every one knows—or at least is easy of demonstration—that if the north and south poles of a small horseshoe magnet be suspended over a bar of soft iron free to revolve in a horizontal plane, or be placed over an ordinary compass-needle, the latter will be attracted at either end by the poles of the magnet and take up a position parallel to a straight line drawn between the two poles of the magnet. Now if the latter be revolved through any angle the soft iron or needle will follow, being dragged around by the magnet, and if the magnet be caused to revolve regularly the iron will also revolve, being pulled around by the full force of the magnet. It was not feasible, however, to cause the magnet to revolve in this way, and Tesla's invention consisted in obviating this trouble and, in fact, in greatly simplifying the problem. He conceived the idea that if he took an iron ring and used two alternating currents, one of which had its maximum value at the instant that the other had a zero value—or, in other words, two currents whose periods were such that one waned as the other increased—he could produce in that iron ring by winding these circuits in alternate coils surfaces that without any mechanical movement of the parts would travel around that ring with a rapidity equal to the number of changes of direction of the currents employed. He thus had a ring, the north and south poles of which were rapidly revolving just as would the poles of the horseshoe magnet were it tied at its middle to a twisted string and allowed to revolve. A piece of iron pivoted at its middle placed concentric with this ring would therefore be dragged around by the changing poles of the ring. He had thus discovered what is somewhat awkwardly expressed by the expression, " the rotary magnetic field," and also the use of what have been termed "polyphased currents"—the one referring to the magnetism and the other to the combination of currents by which this changing magnetism was produced. This discovery is undoubtedly one of the most important that has ever been made within the domain of alternating currents, and marks a most important step in applied electricity; in fact, it may be said to have been epoch-making, for without this method the experiment of transmitting 100 horse-power, 108 miles from Lauffen on the falls of the Neckar to the Frankfort Exposition grounds, in 1891, would have been impracticable.

If two separate currents are employed as Tesla employs them, we have what is called a "diphased" system; if three are employed it is called a "triphased" system; but in speaking of the employment of more than one current the generic term "polyphased" is used. Tesla's discovery is the basis of them all. The Frankfort-Lauffen experiment referred to was operated on the three-phased system. The great scheme of transmitting Niagara's power to distant points, which in magnitude far surpasses the former experiment, will employ the original Tesla diphased system.

His first successful experiment was in 1883, but the first practical motor that showed good efficiency was only obtained in 1887. Ferraris published a pamphlet bearing on the broad principles and some features of the discovery in May, 1888, but six months prior to this, that is in October, 1887, Tesla's first fundamental applications were filed in the Patent Office in Washington.

There is no conflict between Ferraris and Tesla, each according to the other full honor and credit for the work individually done.

As before stated, the discovery of the rotary field has nearly revolutionized the practice of tranmission of energy by alternating currents and the practical value of the invention is fully attested by the adoption by the most eminent experts in the world of the Tesla system for the Niagara electrical plant, by which it is proposed to transmit eventually at least 100,000 horse-power from the falls to various points along the Erie canal, as far as such transmission may prove economical. This invention at once attracted the eyes of the scientific world to Mr. Tesla, who was until then comparatively unknown. He has, however, been an indefatigable worker and has made many inventions which have attracted little attention, often only because of their lesser importance. Mr. T. Commerford Martin, in his exhaustive work on the "Inventions, Researches, and Writings of Nikola Tesla," catalogues 137 inventions or discoveries made by this man. There is not room here for even this catalogue and in discussing his work it will be necessary for me to confine myself strictly to a few of his accomplishments upon which his fame chiefly depends.

Mr. Tesla early turned his attention to phenomena of alternating currents of high frequency and high potential. These brilliant effects which have so much interested scientific men are obtained in his experiments by a peculiar arrangement of condensers and coils, which enables him to obtain enormous potentials of a million volts or more which are alternated in direction many million times a second, if necessary. In the reports of his lectures his apparatus is minutely described, but limited space does not permit me to dwell upon it here. Others had experimented with currents of several thousand volts and as many reversals or more per minute. The phenomena thereby produced were so interesting as to lead Mr. Tesla to explore the field further. He employed currents of hundreds of thousands of volts and having more than 2,000,000 reversals per minute. With these elements at hand he possessed the key with which he unlocked entirely unexplored avenues and produced effects, especially of light, that literally dazzled the scientific world.

Maxwell had taught the world to believe that ordinary light was due to electromagnetic waves of the ether, having a frequency per second of 5 with 14 ciphers after it. He did not prove this, but arrived at his conclusions through mathematical logic. Later Heinrich Hertz proved the truth of these deductions experimentally. This meant that if, by any possible means, we could artificially produce ether waves of this frequency, we would have light without heat and a useful efficiency for the energy expended of about 99 per cent. instead of an efficiency of less than 1 per cent. as obtained in our best gas-burners. We can readily produce etheric waves of a frequency of some hundreds of thousands and even millions, but these fall far short of the requirements in the case, and there were practical obstacles in the way preventing the slightest hope of our ever being able to produce the required frequency or to transmit them if we could produce them. It was Tesla's idea that the desired results were possible of attainment by means of powerful electro-static effects which, by the way, he was able to produce by his peculiar methods and apparatus invented for this purpose and high potentials.

Of course the general bearing of these experiments is upon the problem of an efficient production of light, but in his lectures many scientific facts are pointed out, which contributed to a radical change in scientific opinion in regard to a number of phenomena. So for instance it was demonstrated that a gaseous medium like air, when electric stress of great intensity and frequency were made to act through it, becomes rigid. The agitation produced by the stress in the molecules of the air is such as to render the air luminous, and he produced in some experiments streams of light by merely charging the body. In fact it appears possible from some experiments that a flame might be produced which would appear to be ordinary gas-flame and yet it would be a solid. The phenomenon of the aurora borealis and of the electric storms are usually attributed to the changes of the potential of the sun. A very important fact was demonstrated that in an electrical condenser and in any insulating material, the air must be kept away. As long as this fact was not known it was not possible to properly insulate parts of high tension.

I give here a paragraph on this subject in his own words: *

> But powerful electro-static effects are a *sine qua non* of light-production on the lines indicated by theory. Electromagnetic effects are primarily unavailable, for the reason that to produce the required effects we would have to pass current impulses through a conductor, which, long before the required frequency of the impulses could be reached, would cease to transmit them. On the other hand, electromagnetic waves many times longer than those of light, and producible by sudden discharge of a condenser, could not be utilized. . . . . We could not affect by means of such waves the static molecular or atomic charges of a gas, cause them to vibrate and emit light.
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> *To produce such luminous effects, straight electro-static thrusts are required; these, whatever be their frequency, may disturb the molecular charges and produce light.*

It is to be regretted that lack of space here prevents the elucidation of the terms used, but the fact will be well understood without this, that the production of light practically without heat is within the bounds of possibility. This was Tesla's grand discovery and it was this that dazzled the mental vision of the scientific world. It only remained for him to illustrate his theory by experiments that the physical vision of the world should also be dazzled. He further says:

> It has occurred to me, however, that electro-static effects are in many ways available for the production of light. For instance, we may place a body of some refractory material in a closed, and preferably more or less exhausted globe, connect it to a source of high, rapidly-alternating potential, causing the molecules of the gas to strike it many times a second at enormous speeds, and in this manner, with trillions of invisible hammers, pound it until it gets incandescent; or we may place a body in a very highly exhausted globe, in a non-striking vacuum, and by employing very high frequencies and potentials, transfer sufficient energy from it to other bodies in the vicinity, or in general to the surroundings, to maintain it at any degree of incandescence, or we may, by means of such rapidly alternating high potentials, disturb the ether carried by the molecules of a gas or their static charges, causing them to vibrate and to emit light.

Here are clearly enunciated three distinct methods of producing light by electro-static action, any one of which would have startled the scientific world if founded solely on hypothesis. Tesla's announcement was based on no such unstable basis as this, however; it was based on experimental data which he reproduced before his audiences. Some of these effects had in fact been produced in a feeble way by previous investigators in a somewhat different manner, but it remained for Tesla to bring them out in a far more brilliant way than any of his predecessors and thereby to call attention to their importance that they had not previously attracted. In regard to this, he says:

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* Tesla's lecture before the American Institute of Electrical Engineers, delivered at the School of Mines, Columbia College, May 20, 1891.

> But electro-static effects being dependent upon the potential *and* frequency, to produce the most powerful action it is desirable to increase both as far as practicable. [Tesla was the first to realize and practise this.] It may be possible to obtain quite fair results by keeping either of these factors small provided the other is sufficiently great; but we are limited in both directions. My experience demonstrates that we cannot go below a certain frequency, for, first the potential then becomes so great that it is dangerous; and secondly, the light production is less efficient.

Speaking of what has been termed the bombardment method (the first of the three above mentioned), he says:

> There is no difficulty in reaching such high degrees of incandescence *that ordinary carbon is to all appearance melted and volatilized.* If the vacuum could be made absolutely perfect, such a lamp, although inoperative with apparatus ordinarily used, would, if operated with currents of the required character, afford an illuminant which would never be destroyed, and which would be far more efficient than an ordinary incandescent lamp.

In lamps constructed on this principle, the filament or button of refractory material was connected to but one terminal of the circuit instead of to both as necessary in present practice.

In regard to the second method, Mr. Tesla says:

> The use of alternating currents of very high frequency makes it possible to transfer, by electro-static or electromagnetic induction through the glass of the lamp, sufficient energy to keep a filament at incandescence and *so do* away with the leading in wires. Many forms of lamps on this principle with continuous and broken filaments have been constructed by me and experimented upon.

Thus far he had used in the first case a single connection to the source of energy and in the second no connection at all, but in both cases some refractory material within the globe was brought to incandescence and served as the light-giving body. In the third method, however, he used neither connections nor filaments or buttons, but merely exhausted tubes having no electrodes whatever. Such tubes when grasped in the hands of the experimenter standing near an induction coil became luminous themselves. This seems to be a most remarkable phenomenon, as there is nothing from which the light can emanate. It would seem that the tubes were filled with a luminous substance which was light itself. Speaking of this phenomenon he says:

> In all cases, then, when we excite luminosity in exhausted tubes by means of such a coil, the effect is due to the rapidly alternating electro-static potential and furthermore it must be attributed to the harmonic alternation produced by the machine and not to any superposed vibration which might be thought to exist........In all the last-described experiments, tubes devoid of any electrodes may be used and there is no difficulty in producing by their means sufficient light to read by. The light effect is, however, considerably increased by the use of phosphorescent bodies such as yttria, uranium glass, etc.

But he caps the climax of this brilliant series of experiments by producing conditions whereby a vacuum tube without electrodes may be moved anywhere within the room and, with no connection whatever to the walls, still remain luminous. He says:

> For this purpose I suspend a sheet of metal a distance from the ceiling on insulating cords and connect it to one terminal of the induction coil, the other terminal being preferably connected with the ground; or else I suspend two sheets, each being connected to one terminal of the coil, and their size being carefully determined. An exhausted tube may then be carried in the hand anywhere between the sheets or placed anywhere, even a certain distance beyond them; it remains always luminous.

During this lecture Mr. Tesla performed all of the experiments referred to and many more before his audience and then, summing up his own belief as to their value, he said:

> How far the results here borne out are capable of practical applications will be decided in the future. As regards the production of light, some results already reached are encouraging and make me confident in asserting that the practical solution of the problem lies in the direction I have endeavored to indicate. Still, whatever may be the immediate outcome of these experiments I am hopeful that they will only prove a step in further development towards the ideal and final perfection. The possibilities which are opened by modern research are so vast that even the most reserved must feel sanguine of the future. Eminent scientists consider the problem of utilizing one kind of radiation without the others a rational one. In an apparatus designed for the production of light by conversion from any form of energy into that of light, such a result can never be reached, for no matter what the process of producing the required vibrations, be it electrical, chemical, or any other, it will not be possible to obtain the higher light vibrations without going through the lower heat vibrations. It is the problem of imparting to a body a certain velocity without passing through all lower velocities. But there is a possibility of obtaining energy not only in the form of light, but motive power, and energy of any other form, in some more direct way from the medium. The time will be when this will be accomplished, and the time has come when one may utter such words before an enlightened audience without being considered a visionary. We are whirling through endless space with an inconceivable speed; all around us everything is spinning, everything is moving, everywhere is energy. There *must* be some way of availing ourselves of this energy more directly. Then, with the light obtained from the medium, with the power derived from it, with every form of energy obtained without effort, from the store forever inexhaustible, humanity will advance with giant strides. The mere contemplation of these magnificent possibilities expands our minds, strengthens our hopes, and fills our hearts with supreme delight.

While none of these experiments on light have developed into practical processes, they constitute one of the most remarkable contributions to physical science since the days of Faraday. In the brilliancy of their conception and the beauty of the results obtained we are apt to lose sight of the great inventive genius that was required to devise and prepare apparatus suitable for their public production. Nowhere has the genius of Tesla been displayed to better advantage than in the production of suitable means to the desired ends, and the last public announcement he has made was a description of a mechanical and electrical oscillator by which his investigations of alternating currents would be facilitated.

His lecture of May 20, 1891, echoed around the world and attracted the attention of the gray-haired savants of Europe. He was at once besieged by invitations to repeat his lecture abroad and, on

February 3, 1892, he delivered his lecture with some additions before the most learned men of England, and received at their hands an ovation such as has perhaps never before been accorded to a scientific man. The last public appearance of Mr. Tesla was in a lecture during the Electrical Congress at the World's Fair, which was attended by the principal savants of Europe and America.

But Mr. Tesla is having the experience of all pioneers whose work does not show immediate practical results. One of the leading savants of Europe said to me after Tesla's last lecture: "His work is brilliant, but of what use is it? I would rather see him devote his energies to something more practical."

At this lecture Mr. Tesla exhibited and described a mechanical oscillator in which he had great confidence. He believed that its future possibilities in a practical way were great. He is still of that opinion and, notwithstanding the criticism just quoted, Mr. Tesla says that this invention contains the germ of the most practical work he has ever done. He probably knows best about this and we shall await the outcome with great interest. We are not at liberty to speak freely concerning this invention at this time, but when Mr. Tesla is ready to make an announcement we may hear something startling.

I believe that this sentiment finds considerable response among the scientists abroad. Faraday was constantly met with the question, *cui bono?* and Tesla cannot hope to escape the same experience. Faraday's minute electric spark obtained by electromagnetic induction was his baby. The question was reiterated, *cui bono?* That baby has now grown to man's estate and appears in the form of the 5000 horse-power Tesla generators now nearly completed for the great Niagara Falls transmission plant. The experiments in light, a few of which I have briefly referred to, are Tesla's babies. Who knows how they may appear in mature development?

My own estimate of Tesla is that his is one of the most vigorous and original minds the world has ever produced. Whether he will ever rank with Faraday, whom he resembles in many ways, I do not know, but there is no one in history whose work and character so closely resembles Faraday's to my mind as Tesla's. But Tesla's work is not finished. He is now engaged on something which he tells me he regards as the best work that he has ever done. What it may be the near future will disclose. It is unfair to write one's eulogium until his work is done. Tesla's work, perhaps, has only commenced.

LESSONS OF THE RICHMOND ELECTRIC RAILWAY.

By Frank J. Sprague.

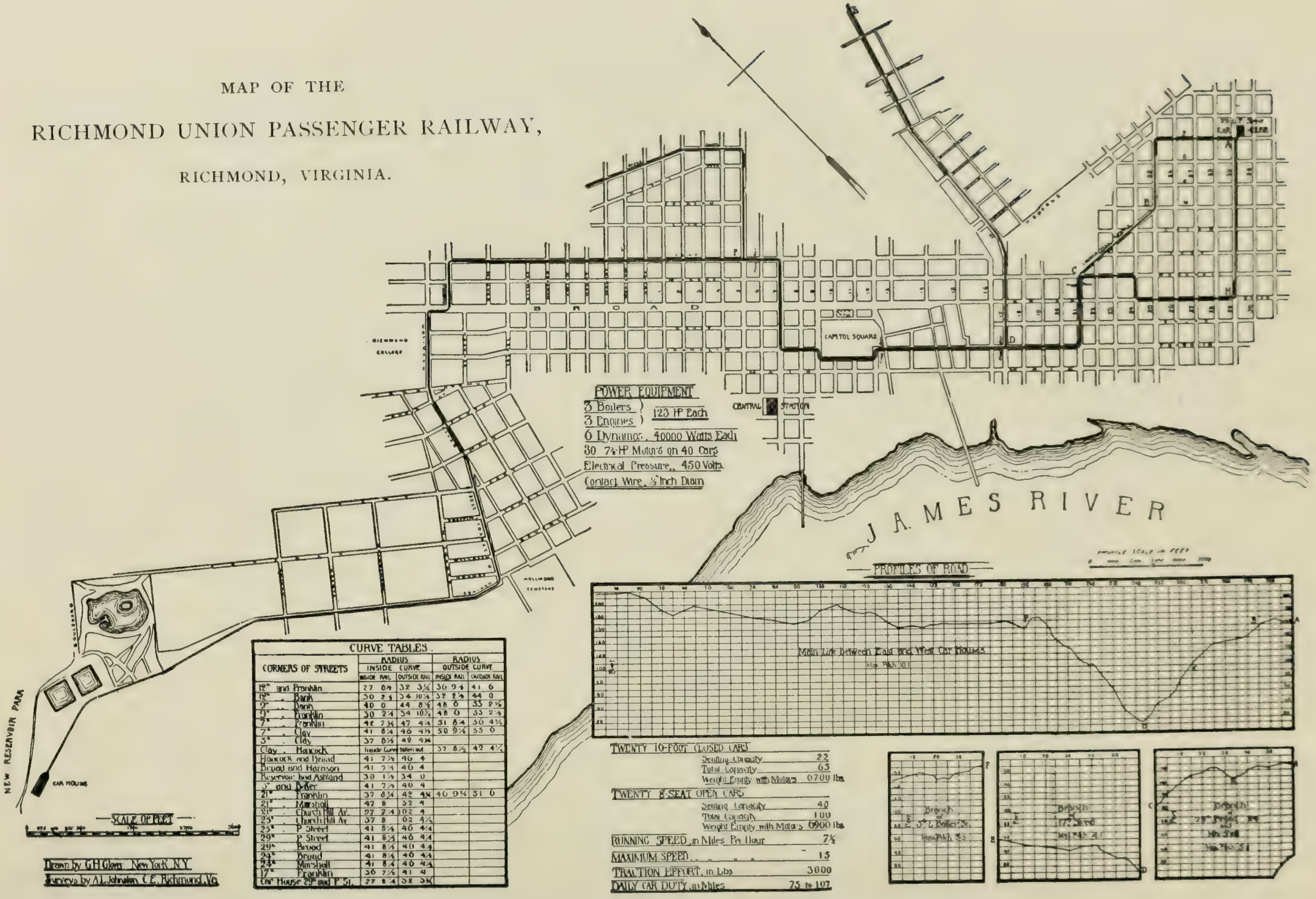
THE year 1887 marked an epoch in one of the most important of modern industrial revolutions, and curiously enough a city in the southern United States was the place selected, largely by chance, for northern capital and enterprise to carry out a grave experiment. Scarcely seven years ago those enthusiastic pioneers who,—poor in pocket and struggling against unbelief and ridicule, yet confident in the ultimate outcome of their endeavors,—proclaimed the future success of electric railways, surely had little enough in the way of practical results on which to base their prophecies. There were altogether perhaps a dozen electric railways of various types in existence; none was so satisfactory as to warrant general adoption, and all were handicapped by their special experimental character. Capitalists, car-builders, railway officials, engineers, offered no encouragement; electricians themselves were in the main doubtful. The electric motor was limited in its applications. It was looked upon as a piece of complicated machinery to be carefully housed and suspiciously watched. It was hydrophobic in character, eccentric in operation. Its construction was crude, its design unsatisfactory, its functions more or less mysterious. The vagaries of the electric current were many, its evasiveness surprising.

When it was proposed to use this agent to overturn the existing tramway systems of the United States,—to put a motor under a car, exposed to dust, moisture, and all the evils of negligent treatment,—there were thought to be good grounds for insanity. To connect it to the wheel by gearing was to violate the laws of mechanics. To govern two or more such machines out of sight was "playing" a lottery. To tempt a wayward current of comparatively high pressure by using the ground as a return was enough to disturb the ghost of Ben Franklin. The ordinary conditions of a street-car service were pronounced an insuperable obstacle to any self-propelled car; a greater than 6-per-cent. grade was declared to be prohibitory. The investment of copper for a multiple-arc system of supply was financially forbidden. Four hundred and fifty volts potential threatened unknown terrors of torture and death, and a bare overhead wire promised innumerable holocausts. Even nature, with its mud, snow, and ice, was to rise in rebellion.

MAP OF THE

RICHMOND UNION PASSENGER RAILWAY,

RICHMOND, VIRGINIA.



POWER EQUIPMENT
3 Boilers } 125 HP Each
3 Engines }
6 Dynamos, 40000 Watts Each
30 7½ HP Motors on 40 Cars
Electrical Pressure, 450 Volts
Contact Wire, ⅜ Inch Diam

TWENTY 16-FOOT CLOSED CARS
Seating Capacity 22
Total Capacity 65
Weight Empty with Motors 0700 lbs.

TWENTY 8-SEAT OPEN CARS
Seating Capacity 40
Total Capacity 100
Weight Empty with Motors 6900 lbs.

RUNNING SPEED, in Miles Per Hour 7½

MAXIMUM SPEED 15

TRACTION EFFORT, in Lbs 3000

DAILY CAR DUTY, in Miles 75 to 107

CURVE TABLES.

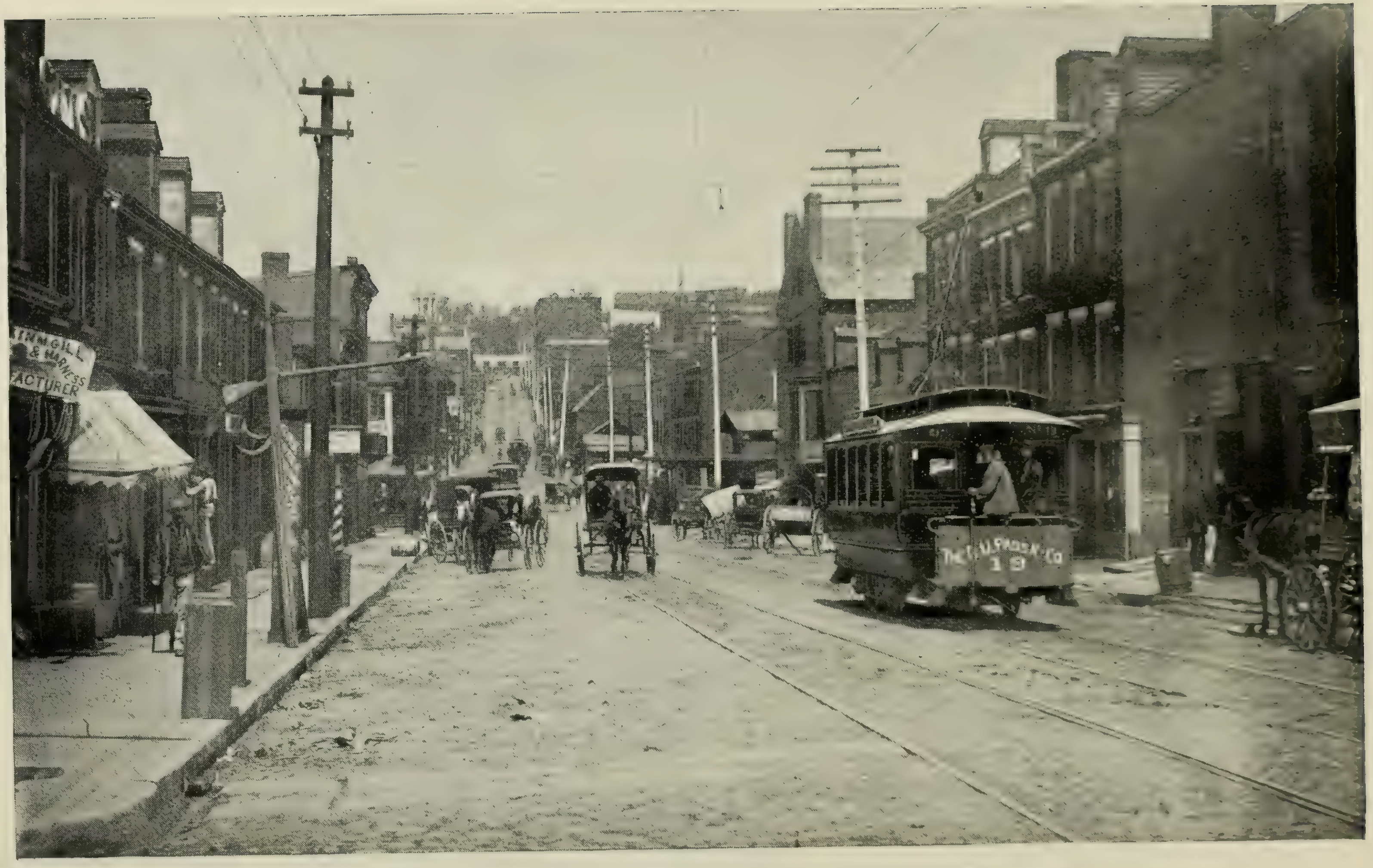
CORNERS OF STREETS	RADIUS INSIDE CURVE		RADIUS OUTSIDE CURVE	
	INSIDE RAIL	OUTSIDE RAIL	INSIDE RAIL	OUTSIDE RAIL
12th and Franklin	27 8¾	32 3½	36 9¼	41 6
12th " Bank	30 2¼	34 10¼	32 2¼	44 0
9th " Bank	40 0	44 8½	48 0	53 2½
9th " Franklin	30 2¼	34 10½	48 6	53 2¼
7th " Franklin	42 7¾	47 4¼	51 8¼	56 4½
7th " Clay	41 8¼	46 4½	50 9¼	55 0
5th " Clay	37 8½	42 4¾		
Clay " Hancock	Inside Curve taken out		37 8½	42 4½
Hancock and Broad	41 7¼	46 4		
Broad and Harrison	41 7¼	46 4		
Reservoir and Ashland	30 1¼	34 0		
5th and Baker	41 7¼	46 4		
21st " Franklin	37 8½	42 4¾	46 9¾	51 6
21st " Marshall	47 8	52 4		
21st " Church Hill Av.	97 7¼	102 4		
25th " Church Hill Av.	57 8	62 4½		
25th " P Street	41 8¼	46 4¼		
29th " P Street	41 8¼	46 4¼		
29th " Broad	41 8¼	46 4¼		
24th " Broad	41 8¼	46 4¼		
24th " Marshall	41 8¼	46 4½		
17th " Franklin	36 7½	41 4		
Car House 29th and P St.	27 8¼	32 3½		

Drawn by G.H.Glenn New York, N.Y.
Surveys by A.L.Johnston C.E. Richmond, Va.

Such was the condition of affairs when, in the spring of 1887, a contract was made between the capitalists representing the Union City railway of Richmond, Virginia, and the Sprague Electric Railway and Motor Company, of New York city. This contract was unique. It called for the completion in ninety days of the equipment of a road at that time unlaid and with a route determined only in part. It provided for a complete steam and electric plant of 375 horse-power capacity, the furnishing of forty cars with eighty motors and all appurtenances necessary for their operation, and a complete overhead system. Thirty of the cars were to be operated at one time, and grades as high as 8 per cent. to be ascended. The price for the equipment was $110,000, to be paid in cash after sixty days "satisfactory" operation.

At the time of taking the contract, the Sprague company had only a blue-print of a railroad machine and some experimental motors used on the elevated road. The hundred-and-one details essential to success were undetermined. Such a contract is one which no business man would ordinarily assume, especially in view of the entirely unprepared state of the company. It was justified by subsequent events because of the pioneer character of the work. Considering all the difficulties which confronted the company, it is probable that, had they been known beforehand and the solution of them unforeseen this contract would never have been made. Fortunately for the future of electric railways the difficulties could not all be foretold and did not have to be met simultaneously. The road cost before completion not less than $160,000, and only $45,000 was paid in cash, with a like amount in bonds. Enormous as this expense was, as grave the risks, the results have entirely justified them all, for the Richmond road stands as the prototype in almost every essential detail of the modern electric trolley system. There was met every difficulty which could be encountered in an overhead system on heavy grades and with sharp curves, and there was settled for all time the question of the economical operation of a large system of street-railways by methods of direct supply.

The limits of this article prohibit more than a reference to the essential features of the new system, the special characteristics of the road, and some personal reminiscences of its development. Briefly speaking, the equipment was what is known as a single overhead trolley system with ground return. The current was distributed by feeders to certain central points from which it was taken by a main conductor extending the entire length of the road, it feeding in turn at intervals of about a thousand feet a working conductor of constant size, one-fifth of an inch in diameter, of hard-drawn silicon wire,



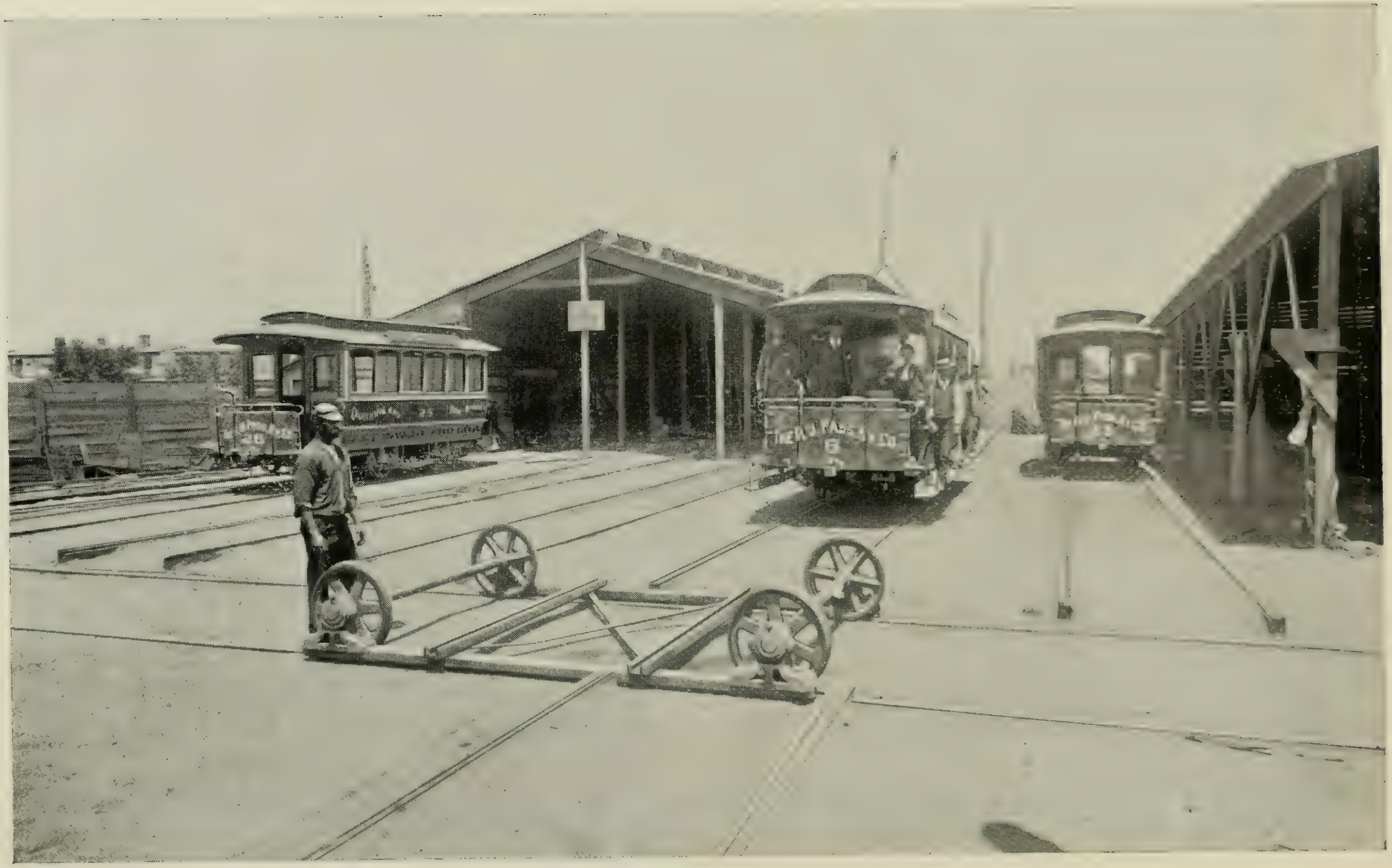
THE FRANKLIN-STREET GRADE, RICHMOND ELECTRIC RAILWAY.

known technically as the "trolley" wire. From this the current was taken by an under-running trolley with upper-pressure contact carried in the middle of the car and having a universally flexible movement. Thence it was carried to the controlling switches on each platform, arranged to control the motors in series or multiple and to make the necessary changes in the field circuits.

The motors, of which there were two, were each centered on a driving axle, directly geared to it with single reduction, and flexibly supported at the free end, so as to allow perfect freedom of movement of the machine while maintaining parallelism between the axes of the car axle and the motor-shaft. Fixed brushes were used on the commutators for forward and back motion. The current, after passing through the motors, went by way of the wheels into the track and thence, partly by the track, the rails of which were connected together and likewise reënforced by a continuous wire, and partly by the earth and the water-pipes and gas-pipes to which the rail system was connected at various points by earth-plates sunk in deep wells, back to the central station. The main features are those which are common to every trolley system of to-day. Some of them, more particularly those relating to motor mounting, had been shown in 1886 in an experimental equipment on the Thirty-Fourth street branch of the elevated railroad in New York city, on some individual cars used for storage-battery tests in New York, Philadelphia, and Boston, and on the initial equipment of the Union passenger railway of St. Joseph, Missouri, which contract slightly preceded that of Richmond, but generally they saw their first application on a commercial scale in the latter city.

A brief inspection of the map of this road and the curve and grade characteristics will give some idea of the difficulties to be overcome, but these formed only a part, and it is fortunate that in the development of this road the writer had the assistance of two young officers, Lieutenant Crosby, a graduate of West Point, and Ensign S. Dana Greene, of Annapolis (which was my own alma mater), who, though entirely inexperienced in electric street-railway work, had energy, pluck, and endurance. It needed all the advantages of youth and enthusiasm, as well as a high technical training, to carry the work through to a successful end. Their work was largely supplemented by that of a number of men who, though not trained engineers, and under adverse conditions and with many hardships, faithfully worked for victory.

Our contract was made in May, and in July I was laid up with an attack of typhoid fever which, with my period of convalescence, kept me away for nine weeks, leaving almost the entire burden on those



RICHMOND ELECTRIC RAILWAY CAR-HOUSE, EASTERN TERMINUS.

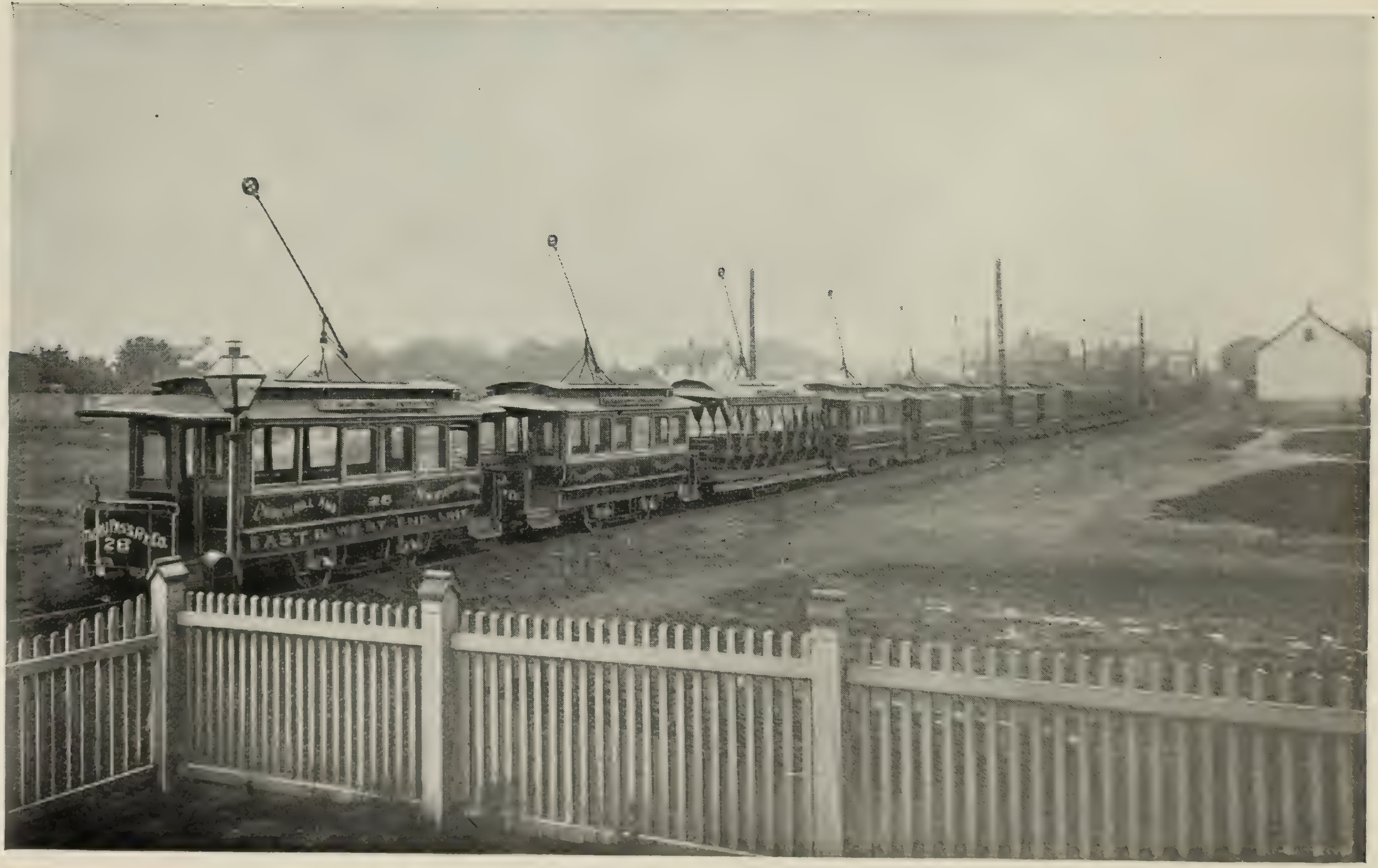
who were associated with me. Returning to duty about October 1, I hastened to Richmond to go over the route and note the condition of the work. Up to that time I had never seen the road. Much of the track-work had been finished, poles had been set, some of the machines constructed, the central station was well under way, and considerable experimental work was in hand. The owners of the road were clamorous to begin operations, while the excuses on our part were without number. I shall never forget the feeling I had when, returning from the improvised car-shed, I stopped at the foot of Franklin-street hill. As I looked up this incline under the bridge connecting the Ballard and Exchange hotels, and saw a grade varying from 4 to 10 per cent. rising above the bridge, I was for a moment doubtful of the outcome, and I began to realize the difficulties, not only those pertinent to our own work but others forced on us by the unusual and unforeseen conditions under which we had undertaken it.

The track was simply execrable, laid for profit, not for permanence, and with no adequate idea of the necessities. It was a flat 27-pound tram-rail of antiquated shape, poorly jointed, unevenly laid in red clay, and insecurely tied together. The total trackage was about twelve miles; it ran in the most irregular way over about nine miles of streets. Part was double- and part was single-track, a part laid on paved streets, but the larger balance on macadam, or unpaved streets. There were twenty-nine curves, five being of less than 30 feet radius. On these sharp curves were grades as high as 8 per cent.; there were straight grades as high as 10 per cent. The outer rails were often inches below the inner ones, and the whole track at times would disappear into the red clay which froze over it and stuck with remarkable tenacity. As I have said, the sight of the main grade was one of my most unpleasant sensations. There were two things which seemed probable. The first was that the car, for lack of track adhesion, would not ascend the grade at all no matter how powerful the machines, and the second was that I knew the latter were lacking in capacity.

Our first machines had been built with one reduction of gearing, to which all street-railway practice is now gravitating. An 8-per-cent. grade would strain them, and a 10-per-cent. grade was probably fatal. Hastening back to New York we held a consultation as to what should be done. The easiest way out of the difficulty seemed to be to run on heavy grades with a cable operated by electric motors in pits sunk beneath the track—a feasible plan if the car could not by its own adhesion mount a 10-per.cent. grade; on the other hand, if it did have sufficient adhesion, then a change in the machines was necessary. The most direct thing which suggested itself was the introduction of an intermediate gear, and, as it was constructed, this proved to be a most serious problem.

Before deciding upon this, the laconic advice of the president of the company, Mr. E. H. Johnson, was "to find out whether the car can get up the grade at all"; this advice was sound enough, and I returned to Richmond to try the experiment. The first test was when we stopped in the middle of a sharp curve with the car apparently locked. I told the manager, Mr. George Burt, formerly of the Panama Railway Company, that I would pull the car out of the curve if it wrecked the machines, and, when called upon, they responded nobly. This was a very convincing experiment to him, although not entirely so to me, because it did not settle the question of track-adhesion. Having got out of our temporary difficulty, we made a run to the foot of the Franklin-street hill, our course being distinguished by a free fight in which an eccentric inhabitant, somewhat the worse for liquor and politically excited, nearly cleaned out our party, until one or two of our best fighting men got into trim, after which we proceeded peaceably.

Arriving at the foot of the hill, we stopped to survey the enemy. When I expressed doubt of the ability of the machines to make the ascent, Burt said: "If you can get out of such a curve as that we just left, you can go up the side of a wall." I knew that even if we succeeded the machines would probably be wrecked, but there was nothing to do but to try it, so, putting on the current, we steadily climbed up this hill, then another, and another around several curves, finally reaching the highest point in the heart of the city. By this time the machines were boiling hot, and we stopped in the center of an admiring crowd in the hope that they would cool down so as to allow us to proceed. No sooner had we started than there was a peculiar movement, then strange but afterwards very familiar, due to a crossed armature, and I knew that we were disabled. We ran on for a block in our crippled condition surrounded by a howling mob who seemed bent on taking possession. Not caring to confess serious trouble, I told Greene in a tone so that I was generally heard that there was some slight disarrangement of the circuits, that he had better go and get his instruments; meanwhile I put out the lights and stretched out in the bottom of the car for a rest. The crowd dispersed and, after a long time, Greene returned with his "instruments,"—four big powerful mules, at that moment the most effective we could get. We soon began our retrograde journey, at first with the mules in the rear, because by cutting out one machine I hoped to get back with the other. Being on the wrong track and with severe grades and

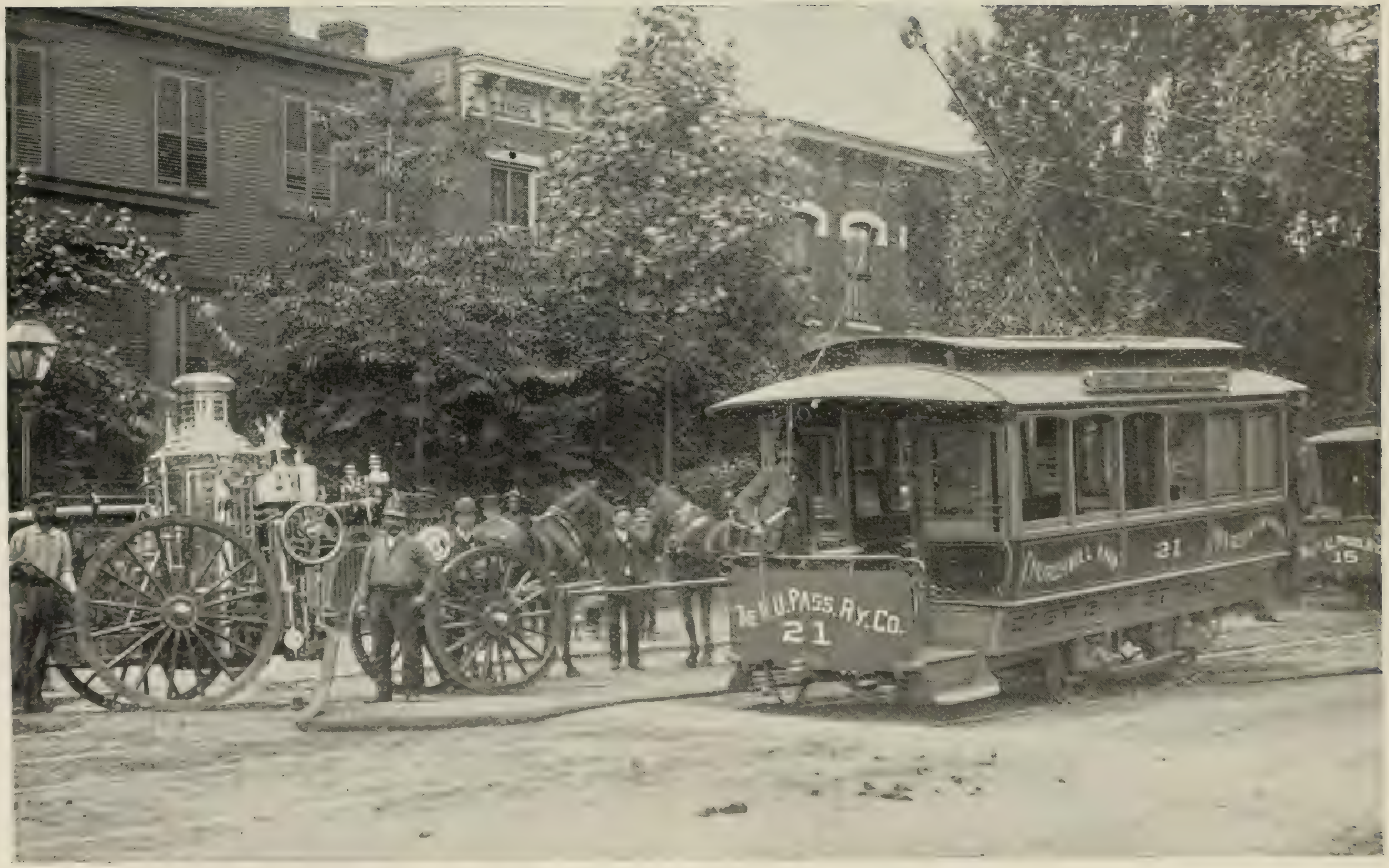


CARS BANKED UP AT EASTERN TERMINUS, RICHMOND ELECTRIC RAILWAY.

curves, I knew it to be a doubtful feat. On approaching one of them on a slight down grade I shouted for every one to jump and give the car a push, put on the full current, and, before I could realize it the car had left the curve and run into the foundation-stones of a hotel. There was no question this time about our being disabled, and we had reluctantly to turn to our mules for assistance. This is but one of many similar night experiences, but, despite our damaged condition, we had settled once for all one problem, and that was that with all the weight of the car used for traction, a 10-per-cent. grade could be ascended ; but having settled this, we were face to face with the necessity of introducing an intermediate gear with a distance between the armature shaft and car axle of only 12½ inches on machines entirely unprepared for any such change. Hastening back to New York it occurred to me to put a stud on one end of the machine carrying a gear and a pinion of smaller size, into the former of which the armature pinion should mesh while the latter should engage the teeth of an internally-split gear on the car-axle. It was a happy thought, for the strain on the stud was largely removed because the moments were equal and opposite on one side. Hastening to the Brown and Sharpe Manufacturing Company, in Providence, R. I., I laid my difficulties before them, representing how vital every day's delay was to me, and gave orders that so far as it was possible, night and day, without regard to expense, they should get out a set of tools and jigs which would permit us to alter our machines in Richmond, and at the same time to make the necessary patterns and to cast the requisite gears. Their response was prompt, and in a few weeks we had removed all of our machines, taken them apart, changed them over, introduced the new gears, and they were again ready for running.

Troubles with gear reduction, serious as they were, formed only a small part of our difficulties. Field-magnets, hastily wound in sections with crude insulation, frequently grounded and crossed. The armatures had a commutator on each end, and were so connected as to bring the brushes at each end on top for easy inspection. Our overhead work was most unsatisfactory. No less than from fifty to sixty designs of trolleys of almost every conceivable shape and character had been brought out. The work of mounting the machines and changing them was conducted practically out of doors, subject to all the inclemencies of a wet Richmond winter.

Into the details of all the work I cannot enter here, but by the end of January the time had come when it was vital for us to start. The owners of the road, taking advantage of our difficulties and naturally disappointed and alarmed, threatened to cancel the contract and forced us to grave concessions. Meanwhile every man had been under in-



ELECTRIC CAR JUMPING THE FIRE-HOSE—RICHMOND, VA.

THE BEACON-STREET LINE, BOSTON.

[The first overhead system in the city; the sequel to the visit to Richmond of Mr. Whitney.]

tense strain; day and night work was the rule. Everything made under this pressure cost vastly more than under any other condition. Changes were frequent, decided upon almost instantly because of the necessity of doing something, and hence without careful deliberation. The road must be made to go; it meant financial ruin for many unless it did. To the railway development its failure would prove a most serious blow. My own reputation and future career, as well as that of my associates, seemed blasted if failure marked the Richmond road.

About the end of the month we prepared to open the road with ten cars. At this time matters were going more smoothly, the overhead work had been gotten into fair condition, the central station was all right. The new gearing was apparently a success, many of the difficulties with machines and switches had been overcome. As a preliminary we spent a day carrying the children of the town and on February 8, 1888, in a drizzling rain, we opened the line for regular service. The day was one of disappointment. The cars, crowded with passengers, would one after another suddenly stop in the street and refuse to move, or to be moved, because of locked gears. A man would go under the car, take off one gear, and continue, if possible, with the other machine, or bodily haul the car off the track so that another could go by. Opinions as to the difficulty were not agreed, but one reliable man, Pat O'Shaughnessy, who has been engaged at work with me for many years, and who is possessed of a most happy mechanical judgment, speedily detected the trouble and was not long in finding the remedy.

Of all the difficulties met, one of the most exasperating was that connected with running with fixed brushes. For a long time it seemed almost as if this would prove a failure. The armatures were continually grounding or crossing, and one of the commutators was particularly badly burned, the mica itself being charred and the copper blistered. After a time we found that this was largely due to the fact that the current always went into one brush and out at the other, and then we adopted the practice of reversing the armature circuits instead of the fields for a change in direction.

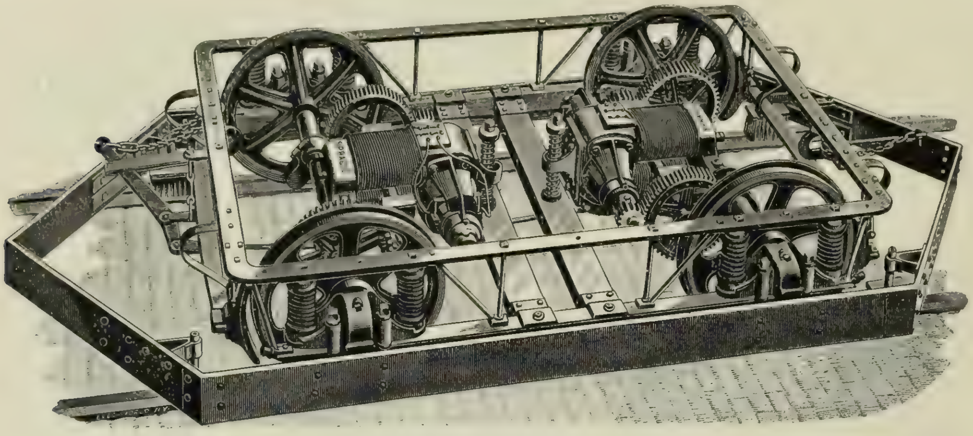
It seemed, however, that we had no copper commutator good enough, and there followed a change of every commutator on the road. Not only special forms of commutators were made, but special materials were made in various places. Before the final adoption of carbon, the variety of brushes tried was without number ; sometimes flat ones, solid and laminated, which would wear through, double over and hug

"THE RIVALS."

[Sprague car under 11-foot railway bridge, Steubenville, Ohio.]

an arc of the commutator, or oblique, solid, and laminated brushes which would catch in the bars, reverse or split, and straddle the commutators, with the direct result of ruin to commutators, crossed armatures, and burned-out fields. It was a daily occurrence to see a loaded car climb a grade with a lurid green glare lighting up the track, but with no possibility of getting at it, although I knew that $100 worth of damage would be the result of the trip. Then we tried tilting brushes and variously-shaped pieces of copper, bronze, and brass set on end, and pressed down by all sorts of springs, and finally solid bars of brass set on end.

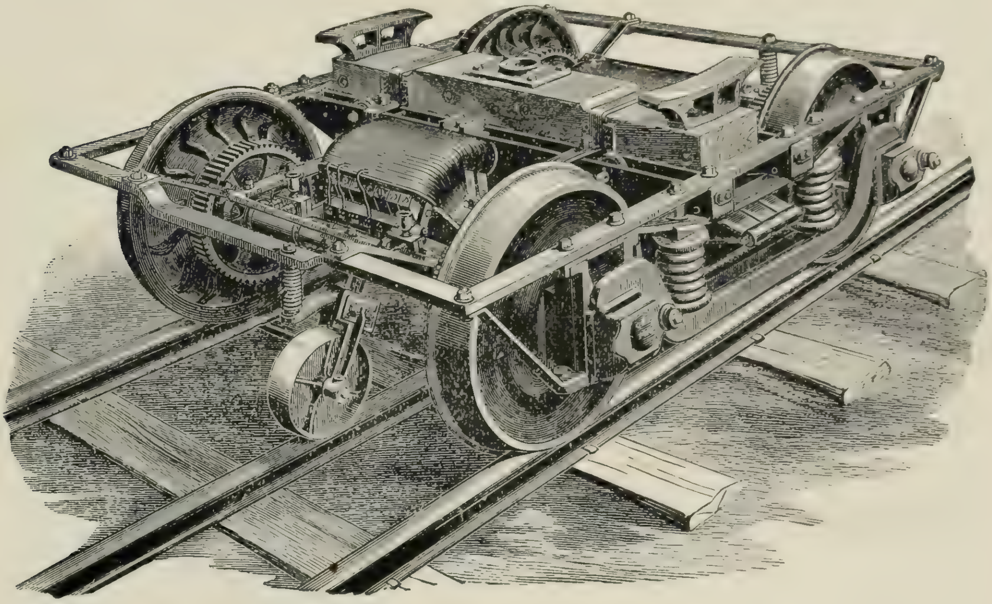
About this time $9 worth of brass per day, milled off by the rough bars of the commutator, lined the track with a glittering path; not a single trip was made without inspection, with generally a change of brushes or some other repair. But this was not all. Every armature was unwound, the bodies shortened, and then rewound. Disabled armatures were numberless, and to keep the road in operation tons of machinery were shipped by express. Frequent change of parts were necessary, and, since the machines had not been built on the interchangeable principle, in a few weeks they were of the most heterogeneous character.



VIEW OF INDEPENDENT TRUCK, EQUIPPED WITH SPRAGUE ELECTRIC MOTORS.

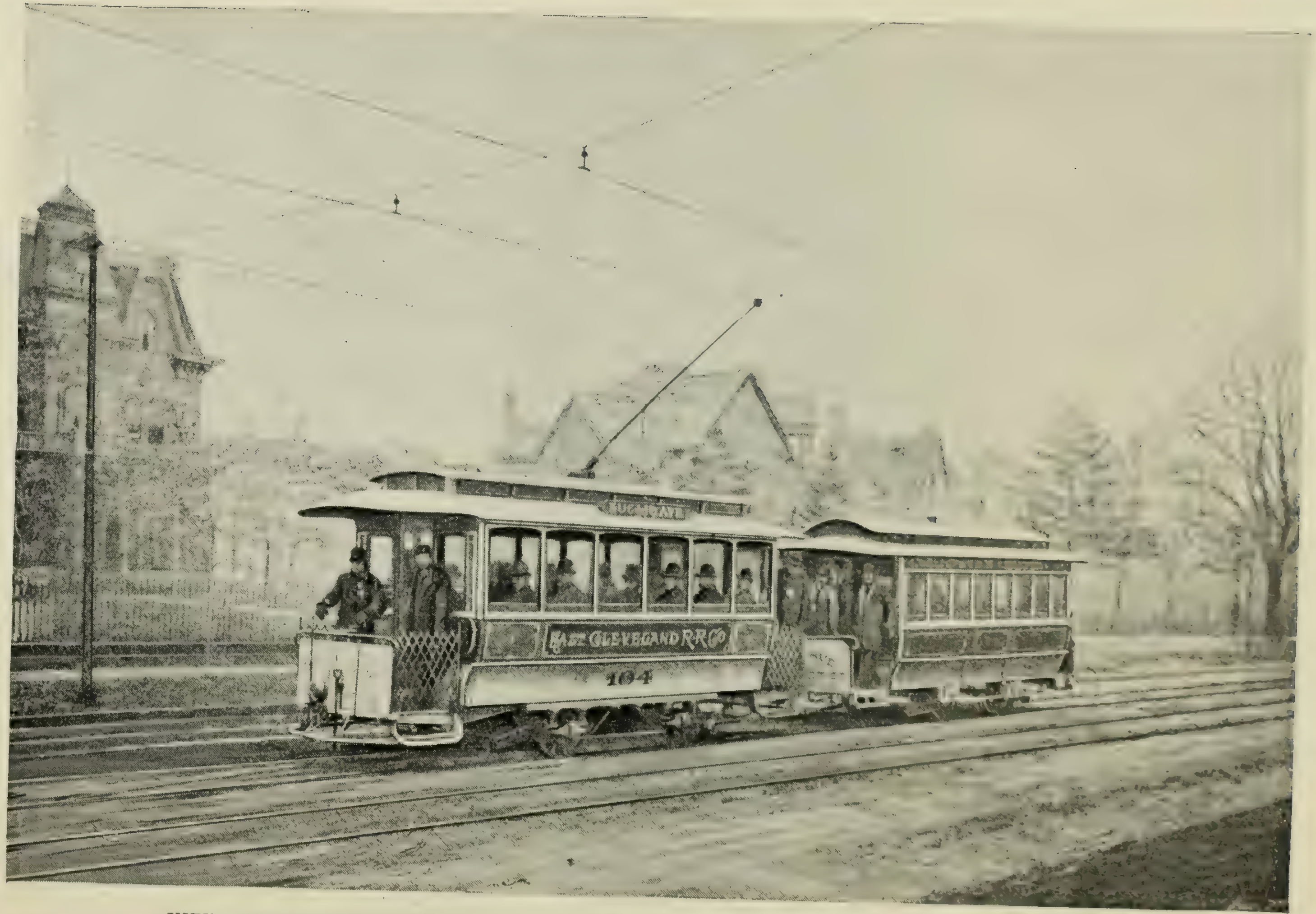
We managed, however, to keep the cars going, and gradually we saw our difficulties lessening, although new ones would crop up, and little by little the number of cars in operation was increased from ten to twenty, then to thirty, and finally one of our most reliable men, David Mason, put forty cars into operation, or ten more than the station or line equipment called for. In the three months of operaation from February until May, 1888, despite innumerable changes and troubles inconceivable, no car in Richmond was pulled a foot by animal power, for if any accident occurred to a motor the car went along with the crippled machine or with one good one, oftentimes with the heaviest loads and on the sharpest grades, and in some cases in tow of another car. One hundred and forty men, often with only a day's training, were soon broken in to handle the various parts of the system.

Saturday, May 4, was a red-letter day in our calendar. On that day, in the afternoon, when traffic was heavy, we put on ten additional open cars, finally banking them up near the western terminus. Just at dusk eleven cars at close headway were run at full speed down one of the principal streets, and an hour later thirty cars, many of them heavily loaded, were in full operation. Three boilers, rated at 375 horse-power supplied not only the railroad dynamos but lighting dynamos with an equivalent load of over 1000 lamps.



TRUCK OF SPRAGUE CARS.

The highest reading on the line was less than three-quarters of the normal capacity of the dynamos, and the average reading only one-half. This test settled conclusively all question as to distance, speed, and power, and practically ended the discussion as to the merits of the series and multiple-arc systems of distribution. Fatigue, worry, and expense were all forgotten for the moment, such was the keenness of enjoyment in an assured victory. Subsequently one of the most beautiful sights that I had witnessed for a long time was the assembling of sixteen cars in the center of the town at night by reason of a mistake in the time of ending of an entertainment. This, too, was a most important demonstration upon the public mind of the possibilities in the line of work we were pursuing.



VIEW OF ONE CAR DRAWING ANOTHER ON EAST CLEVELAND RAILWAY, CLEVELAND, OHIO.

Another important experiment in banking cars occurred on the occasion of the visit to Richmond of President Henry M. Whitney and a number of the directors of the West End railroad of Boston, then seriously considering the adoption of the cable system. For lack of better shelter the cars were banked out of doors at the eastern terminus. On this particular night twenty-two cars were so collected.

General-Manager Longstreet, of the West End road, having expressed doubts as to the handling of the cars electrically when bunched together, Burt and I made up our minds we would settle the question by a critical experiment, although it was overtaxing the line many times over. Mr. Whitney had retired, but on receiving word about midnight that we were willing to make such an experiment, he immediately arose and we were soon on our way to the eastern sheds, two miles from the station. The current supply was by two paths over a silicon-bronze wire one-fifth of an inch in diameter, reënforced by another wire of about the same size. We loaded the feeder safety catches, raised the pressure to 500 volts, and ordered the engineer to hold the machines to duty no matter what happened. At the wave of a lantern, 22 motormen as quickly as possible started their cars at the termination of a line calculated for only four distributed cars. The potential dropped to 200 volts, then gradually rose, and soon all the cars were running out of reach of signals. This settled the cable question for Boston, and we shortly secured the contract for the first overhead line in that city.

Richmond was prolific in new experiences which in variety and extent taxed our resources to a degree happily unknown on modern roads. Many were not inherent to the machines or the system, but were caused or augmented by local conditions. One of the most annoying was the jumping of the cars from the track. As has been stated this was not only largely laid in dirt streets, the soil of which was of red or yellow clay, but the curves had only one guard-rail and were not bound in by paving. The winter months brought frequent and heavy rains, the cars were large and heavy, and in a short time the curves spread. Mud and stones would get into the grooves, and, on account of the tangential tendency of the cars, before an inexperienced man could check them they were off the track and the wheels were down several inches in the mud alongside the stringer pieces, and the track-brakes hard fast.

For some time scarcely a trip was made without the cars jumping the track, and a heroic treatment was at first adopted which gave them the appearance of battering-rams. Twelve-foot sticks of timber and scaling-ladders were carried under the car-bodies, and when a car left the rails and tried to bury itself in the mud, all hands, often aided by the passengers, pried it back into place. Gradually the soft places were filled up with cinders, the track rectified, the curves paved, and we soon learned to get a car back by using track-plates and completing the ground circuit by a flexible cable which we termed an "electric kedge."

The bugbears of sleet, snow, and mud were frequently raised; it was impossible to keep the tracks from being thickly covered by the crowding of the passing vehicles, and when a sharp change of weather occurred at night the cars in the morning would play leap-frog with brilliant pyrotechnic displays. Virginia mud clung hard to cold iron, and it was a common thing to have to cut through clay, snow, and ice when the tracks were completely out of sight.

On one of the worst nights of winter I had gone to bed completely played out after a vain attempt to get the "Snowflake," our construction car, up a 6-per-cent. grade on a slippery track with one motor, and had finally left it in the street for the morning's work. Dawn brought dismay, for tracks, trees, and trolley wire were covered with a heavy sleet. Not a car was in operation, and everything looked hopeless. In desperation I boarded my pet car, swept off some of the snow, wiped off the motors so that there was only a moderate display of leaks, and started to make the best of my way to the power-house. The sun had come out, water was dripping from the pendant icicles, and when I turned the corner at the head of the Franklin-street grade, my astonished eyes were gladdened by the sight of a car slowly climbing the 10-per-cent. grade with Pat on top pounding the trolley wires with a broom and making the sleet drop off in great lengths. That settled the sleet question, and we gave ourselves no more concern on that account.

Thunder-storms are particularly severe in Richmond and this brought us new anxieties. The length of the overhead circuit, the unguarded condition of the wires, and the numerous ground connections offered by lamps and motors invited frequent discharges. We awaited the result of the first attack of the heavens with interest. Like many other anticipated troubles, so far as they related to danger to life our apprehensions were quickly allayed.

In one of the first storms lamps were broken, field-magnets grounded, and switches burned out. On one occasion three men were sitting on the rear platform, one with his legs probably dangling over the switch, when there was a sharp flash and a loud clap, accompanied by a peculiar report in the switch beneath him where the discharge jumped to earth. Three terrified darkies disappearing as fast as their legs could carry them up the street was the sequel. As a rule, however, little personal difficulty was experienced because of this trouble. Passengers often did not know when the lightning discharged through the car circuits, or, if they did, they quickly got used to it.

We found that the lamp-circuits offered a very free path, so when a thunder-storm appeared the lamps, ostensibly to light the car as was carefully explained to timid lady passengers, were turned on and the lightning given free play. The armatures being on the ground side of the circuit were rarely injured because the fields acted as choking coils and forced the discharge to earth at some weak point. Lightning-arresters without number and with varying degree of success were introduced, but the lightning always remained more or less erratic.

Such are some of the reminiscences of Richmond days. The infant industry of seven years ago has grown to manhood and marks one of the most important of modern industrial advances. Six hundred railroads, 25,000 motors, and an investment of a quarter of a billion of dollars speak of its marvelous growth. The days of the horse-car are limited. The cable is restricted to special localities. In suburban service already the electric car rivals the locomotive, and the latter is being gradually forced to its legitimate field of through trunk-line and freight service.

THE CYANIDE PROCESS OF GOLD AND SILVER EXTRACTION.

By Philip Argall, M. R. I. A.

GOLD was in all probability one of the first metals to attract the attention of primitive man. Its beautiful and permanent luster, its high specific gravity, and its comparative scarceness withal, must have early rendered it an article of *vertu*, the search for which meant labor, and its possession wealth. The vessels of gold found in the Egyptian tombs, together with the drawings on their walls, give evidence of the advanced state of the metallurgy of gold long before the time of Rameses II. The Hebrew scriptures abound with references to the metallurgy of gold and silver, and particularly to the refining or cupellation process, evidently referred to by Jeremiah in: "The bellows are burned, the lead is consumed of the fire, the founder melteth in vain." The early Greeks were familiar with the natural alloy of silver and gold—electrum—rough-stamped nuggets of which formed the earliest coins of Lydia. Mercury, mentioned by the Greek philosopher, Theophrastus, as a derivative of cinnabar (300 B. C.), was used by the Romans in the time of Pliny, both for the separation of the precious metals, and for the purpose of gilding.

Smelting, then, appears to be the older metallurgical process; next would come amalgamation, while hydro-metallurgical methods are apparently of very modern origin. I say apparently, for now that the Egyptian temples, tombs, and ruins, furnish evidence that diamond-core drills, circular saws, hot-blast stoves, etc., were known and used 3000 to 4000 years ago, one cannot be certain that even the cyanide process itself is not a re-invention, at least until the Egyptologists are heard from.

In these degenerate days gold is recovered from its ores by amalgamation, by smelting, or by hydro-metallurgical methods. The first-named process is seldom entirely satisfactory, as the extraction is invariably more or less imperfect. It is therefore usual to precede or follow amalgamation with a process of concentration, to remove the heavier minerals that do not readily yield their gold to mercury. The concentrates so obtained are treated by the smelting process, or by hydro-metallurgical methods.

Smelting* gives the highest practicable extraction of gold and silver from their ores, but usually at the greatest cost, while amalgamation—taken by itself—is the antithesis of smelting, as it may be said to give the lowest extraction at the least cost; nevertheless, on low-grade silicious ores, it is the more profitable of the two methods, and the one in general use.

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*Lead-smelting was described in the March number of this Magazine by Mr. W. R. Ingalls, and pyritic-smelting in the April number by the present writer.

The hydro-metallurgical treatment of gold-ores has been steadily gaining ground for several years past, not alone in the treatment of concentrates and tailings, but also in the direct treatment of auriferous ores. Where the gold, by reason of its extreme fineness or the allotropic modifications of its molecules, or for other causes, will not amalgamate, and where the economic conditions that obtain do not permit smelting, recourse has usually been had to hydro-metallurgical methods, noted examples being the Mount Morgan mine in Queensland, where amalgamation gave such poor results that it had to be abandoned in favor of chlorination, and the Mercur mine, in Utah, where amalgamation is said to have extracted but 25 per cent. of the gold in the ore, at an expense of $4.25 per ton, while the cyanide process that replaced it is reported to give 80 to 85 per cent. of the gold, at a cost of $2.40.

Chlorination has held hitherto the first position among hydro-metallurgical methods of gold extraction, but it must now take a second place in favor of its powerful rival, the cyanide process, if measured by their relative gold production. The cyanide process, while suitable to perhaps the majority of gold-ores, is not applicable to all. On certain classes of ore, and under certain well-known conditions, chlorination will give better results than will cyanide, and again the converse is true. Each process, then, has its field, at present perhaps but ill-defined, but which will shortly be marked with precision.

It is generally supposed that certain classes of sulphid and telluride ores which do not yield their gold to cyanide solutions within reasonable time, or with a reasonable expenditure of chemicals, should be treated by the chlorination process; it being argued that once it becomes necessary to roast the ore, chlorination is cheaper than cyaniding. This supposition is not strictly correct. Careful experiments have shown that such ores are often amenable to cyanide treatment after an extremely light roast, and that with proper expedients the consumption of cyanide in leaching the roasted ore is not abnormal. To chlorinate these ores a dead roast is a prime requisite, while the expense of the subsequent chlorination treatment will, in most cases, exceed the cost of cyaniding. Another important feature: the chlorine will extract gold *only*, while cyanide invariably extracts a large proportion of the silver in the ore, in addition to the gold.

The cyanide process is based on the solubility of gold and silver in solutions of potassium cyanide (KCN); this salt is composed—as shown by the formula—of potassium, carbon and nitrogen, though the symbol Cy is commonly used, instead of the formula CN, to represent the radical cyanogen, which combines like chlorine with hydrogen and the metals. Roscoe compares its compounds with those of chlorine thus:

Hydrocyanic acid, CyH.	Hydrochloric acid, ClH.
Potassium cyanide, CyK.	Potassium chlorid, ClK.
Potassium cyanate, CyOK.	Potassium hypochlorite, ClOK.
Free cyanogen, $\mathrm{Cy_2}$.	Free chlorin, $\mathrm{Cl_2}$.

Hydrocyanic acid is so weak an acid that its soluble salts are readily decomposed by the carbonic acid of the air. Potassium cyanide is no exception to this rule, as its solutions decompose in contact with the air, and smell of hydrocyanic acid. Any weak acid or acid salts will also decompose cyanide solutions, and to this fact many of the chemical difficulties in the application of the cyanide process are due. If the ore is acid, it causes an increased consumption of potassium cyanide, and as this salt costs 50 cents per pound, any abnormal consumption cuts rapidly into the margin of profits.

It has long been known that gold is soluble in cyanide solutions. Hagen, for example, pointed out in 1805 that gold is dissolved not only by free chlorin and *aqua regia*, but also by a potassium cyanide solution. Glassford, Napier, Gemelin and others mentioned the solvent power of cyanide on gold and silver, in the early part of this century. The classic experiments of Faraday on the relation of finely divided gold to light are well known. Suffice it to say, that films of gold-leaf of extreme tenuity were obtained by spreading the leaf gold on glass plates and subjecting them to cyanide solutions. Roseleur also pointed out that solutions of cyanides "rapidly dissolve in the cold, or at moderate temperature, all the metals except platinum."

Although the solubility of gold in cyanide solutions is no recent discovery, and although several attempts appear to have been made to introduce a process having potassium cyanide—usually in combination with another salt—as a solvent for the gold, it remained for Messrs. McArthur and Forrest to introduce a commercially-useful process for treating ores with cyanide solutions. This process has been extremely successful in South Africa; fairly successful in some other countries, and until recently has been, on the whole, rather unsuccessful in the United States.

The cyanide process in South Africa has been used almost exclusively in the treatment of tailings from the stamp-mills, in which ordinary battery-amalgamation is practiced. The ores, while unfavorable for efficient amalgamation, are particularly suitable to cyanide treatment, consisting of silica and iron oxid almost to the exclusion of any substance—except gold or silver—soluble in cyanide of potassium solutions. As the reefs are followed downward, however, pyrite replaces the iron oxid and the ores become base—with what result on the cyanide process remains to be seen. One of the largest mines in South Africa (the Robinson) has for some time treated the pyritic concentrates from the stamp-mills by the chlorination process, while using the cyanide process on the tailings. During the half year ending December 31, 1893, this company milled 94,842 tons of ore with the following result:

	Ounces.	Percentage.
Gold produced from milling	104,223	78.5
Gold produced by chlorination of concentrates.	10,660	8.0
Gold produced from tailings, cyanide process.	17,992	13.5

The cost of cyaniding the tailings amounted to $1.57 per ton, distributed as follows:

Wages and supplies	$0.899
Cyanide	0.483
Zinc	0.026
Royalty	0.163

[The extraction is reported at 68.7 of the contained gold.]

During the same half year another South African company (the Durban-Roodepoort) treated 79,765 tons of tailings by the cyanide process at a cost of $1.53 per ton and profit of $2.77 per ton. The extraction varied from 67 to 85 per cent. of the gold.

The South African Gold Recovery Company, which controls the cyanide process there, reports the extraction in the Transvaal for the month of May, 1894, at 57,850 ounces of gold, and states that the process is producing 30 per cent. of the total yield of gold in the Witwatersrand district. During the five months ending May last, the cyanide process alone produced 273,450 ounces of gold in the Transvaal. It must be noted that the fineness of the gold is not stated. I find, however, that the cyanide gold averages about $15 per ounce,—say .726 fine,—while the mill gold of the district is about .867 fine,—say, about $17.90 per ounce.

The foregoing figures show conclusively that the cyanide process, under favorable conditions, is capable of accomplishing very wonderful results, and that it has made more rapid strides than perhaps any other process hitherto introduced for extracting the precious metals from their ores. We must not, however, lose sight of the fact that the process is applied in South Africa to the treatment of battery sands, from which the extremely fine slime has been removed; the process is not, therefore, charged with the crushing or preparation of the ore, while the material operated upon is of comparatively low value, say $5 to $7 per ton, giving a final tailing value of $1.50 to $2.00 per ton.

Seeing that the cyanide process has had its greatest development and achieved its best commercial success as an auxiliary to amalgamation, the question arises, can ores be treated direct with cyanide? Is the cyanide method complete in itself, or merely a new step in the successful treatment of gold-ores? It is both. For example: When the gold in the ore is coarse and granular, amalgamation either before or after the cyanide treatment is imperative. For it is well known that cyanide solutions (in common with chlorin) take a very long time to dissolve coarse gold. If, however, the gold is fairly fine, cyanide usually answers all requirements, and with suitable ores, properly prepared, gives a high rate of extraction at moderate cost and in reasonable time. In some cases, then, ores can be directly treated by, and finished with, cyanide; while with other ores, amalgamation is a necessary step in order to remove coarse gold, shorten the lixiviation part of the process and reduce the consumption of cyanide, which, after the first half hour, increases in proportion to the time its solution remains in contact with the ore. In other cases concentration is advisable. For example: An ore may contain 15 per cent. of pyrites, which may require special treatment in the way of a stronger solution, or long exposure to solution—say 80 hours—in order to obtain a good extraction; while the remaining 85 per cent. of the ore may have its gold dissolved in twenty-four hours. Here, then, separating the heavier from the lighter particles, and subjecting each to separate treatment, will result in a gain of time in lixiviating, saving of chemicals, and increased capacity of the works.

The same line of argument holds good if the concentrates cannot be successfully treated by cyanide, as in this case a deleterious material is removed from contact with the cyanide solution, to be handled by such other methods as the particular circumstances will indicate. The cyanide process, then, can be applied to ores direct, or as a combination process with amalgamation or concentration, or both, as may be found most convenient and profitable for the economic treatment of the ores.

For the purpose of description, the cyanide process can be conveniently divided into four distinct stages or steps: (1) The preparation of the ore; (2) solution of the gold; (3) precipitation of the gold from solution; and (4) converting the precipitate into bullion.

I. The preparation of the ore consists in reducing it to the size necessary to give the desired extraction. This size varies considerably in accordance with the character of the ore, but may be said to run from 20- to 60-mesh. The ore is usually crushed dry, though wet-crushing is sometimes practiced, and on some ores presents decided advantages over the dry method. The ore must be crushed so as to produce a fairly even and granular material, as free as possible from dust when dry-crushing is practiced, and equally free from slime if crushed wet. This granular product is not easily obtained from the crushing-plant usually adopted, and to this fact most of the failures of the cyanide process in the United States are due. We hear in such cases that the extractions in laboratory tests were highly satisfactory, and indeed that the mill extractions were also excellent but "the ore would not leach," therefore, while the gold was readily obtained in solution, it was impossible to separate the auriferous solutions from the pulp, and hence the alleged failure of the process. I will give two instances by way of illustration: A certain mill, abandoned as a failure on account of leaching troubles, proved on investigation to have crushed 67 per cent. of the ore fine enough to pass through 200-mesh—0.0025-inch openings—while ostensibly crushing to 30 mesh. In another case, I found that 42 per cent. of the pulp would pass 200-mesh. In both cases, leaching was impracticable. Proper machinery was afterward placed in these mills, with the result that the former produced a pulp having only 8 per cent. passing 200-mesh, and giving a leaching rate of 8 to 12 inches per hour; the pulp produced from the latter mill gave also a very excellent leaching rate. Both mills are now running satisfactorily.

Successive comminution is the correct principle to adopt for the preparation of pulp for the cyanide process. The best results hitherto obtained, on rather friable oxidized silicious ores, have been produced by the following series of machines: (*a*) an ordinary Blake crusher, which reduces the ore to about 1½ inches; (*b*) a three-jaw multiple Blake crusher, which brings the ore down to ¾-inch; followed by (*c*) a five-jaw multiple that reduces it to about 6-mesh; and (*d*) rolls that finish the pulp to pass a 30-mesh screen. The ore is screened after each crushing, so that the portion reduced to the desired fineness passes direct to the finished-ore bin, instead of—as is too often the case—going to the next machine to be reduced to a further and unnecessary degree of fineness. This plant, crushing to 30-mesh, produces only from 5 to 10 per cent. fine enough to pass 200-mesh.

Soft, clayey ores have hitherto given much trouble, and, in fact, it is usually impossible to leach them, not alone on account of the dust produced in reducing such ores to pulp, but often because of the amount of dust existing in the ore before crushing. These difficulties have been overcome by separating from the pulp such an amount of dust as is found necessary to give a good leaching rate, and subjecting this separated dust to a special treatment. It has been found that the removal of as little as 5 per cent. of the extremely fine dust will often give a fair leaching rate on pulp that before its removal could not be leached; while the worst case I have met with did not require the removal of over 15 per cent. of this dust in order to obtain a good percolation rate.

The preparation of the ore, then, is a very important step in the direct treatment by the cyanide process, and one that has only been brought to its present state of perfection within the last six months.

II. The solution of the gold is effected in leaching tanks, which are preferably constructed of steel. These tanks are made from ten to forty feet in diameter, and from three to four feet in depth. Some prefer wooden tanks, as the cyanide solution attacks steel—very feebly, it is true—and gold may be precipitated on the sides of the tanks. These objections are quasi-theoretic and have no practical bearing on the process. It has been proved that steel tanks coated with paraffin paint meet all practical requirements, and are the best to use under all conditions.

The leaching tanks are fitted with filters in the usual manner; side or bottom discharge-gates are provided for sluicing out the tailings. A leading and return pipe of iron should be provided for each solution used in lixiviating. The granular ore is charged into the leaching tanks to the depth of two-and-a-half to three feet. The ore, of course, varies in weight in accordance with its composition; about 80 pounds per cubic foot, however, is a fair average. On this basis, a 40-foot tank would hold 50 tons per foot of depth, while a 20-foot tank would hold 12.5 tons per foot. A small tank for dissolving the cyanide, large storage tanks for weak and strong solutions and for wash water, are part of the equipment of the leaching department.

To obtain the best results, the ore should be neither acid nor alkaline; if the former, it decomposes the cyanide solutions in the leaching tanks, and, if strongly alkaline, it causes an increased consumption of zinc, and, indirectly, of cyanide in the precipitating boxes. When ore gives an acid reaction, lime is sometimes added to it in the crushing machines, or the pulp in the leaching tanks is treated with an alkaline solution, or with water to dissolve the acid salts. After the preliminary leaching with water or alkaline solution is completed, cyanide solution of the required strength—usually 0.25 to 0.50 per cent. for gold ores, and 0.60 to 1.50 per cent. for ores carrying much silver—is admitted below the filter and allowed to slowly percolate upwards and rise to a height of three inches above the upper surface of the charge. This solution is allowed to stand on the ore from eight to twenty-four hours and is then drawn off and passed through the precipitating boxes. Weak solution is then added and lixiviation continued until the maximum extraction is obtained, when wash water is introduced above the charge to displace the weak cyanide solution. The discharge-gates are then opened, the pulp sluiced out of the tank and the next charge added.

Agitation of the pulp and cyanide in open vessels was the method originally proposed. This method has, however, not proved very satisfactory because of the heavy loss of cyanide through decomposition, caused chiefly by the admixture of air with the solution, and also on account of the difficulty in separating the solution from the pulp. Agitation, however, invariably gives a better rate of extraction and procures the solution of the precious metals in fully one-third less time than is usually occupied in tank lixiviation ; moreover, some ores, such as those carrying their principal values in silver, or gold and silver sulphids, or tellurides, often fail to give a satisfactory extraction by the lixiviation method, while by agitation they are readily beneficiated.

By the use of barrels instead of open vessels, and with ores properly prepared in granular form, the agitation process will no doubt be revived and will, I believe, yet become the leading method for the direct treatment of ores in the United States.

III. The gold is precipitated from the cyanide solution by means of zinc shavings so placed in the precipitating boxes that the solution, in flowing through them alternately, passes upwards and downwards through the loose mass of zinc. These boxes are usually made of wood, but could with advantage be constructed of glass, earthenware, or cement. No iron or metal other than zinc should be exposed to the solutions in the boxes ; even the iron-wire screens used to support the filiform zinc have been shown by Mr. N. Andersen, of Denver, Colorado, to cause an unnecessary consumption of zinc and cyanide, through the electrochemical action induced between the metals.

The precipitation boxes are made in lengths varying from 40 feet down to 5 feet. Long boxes are a mistake. They should in no case be longer than is necessary to precipitate the gold from solution,—a result that can be readily obtained in an 8-foot box. The exposure of the solution to the zinc after the gold is precipitated only can result in a loss of zinc, and what is of much greater importance, unnecessary decomposition and loss of cyanide. The cyanide solution, after passing through the precipitating boxes is pumped back to the storage tanks and brought up to the required strength by the addition of strong solution from the dissolving tank. The standardized solution is then ready for use in the leaching tanks. The solution, then, is used continuously and not run to waste when the gold is precipitated as are the solutions from chlorination works. The zinc dissolved in the precipitation boxes does not accumulate in the solution beyond the fraction of 1 per cent. As we do not find that zinc accumulates in the storage tanks, it is probably precipitated in the lixiviation tanks in contact with the charges of fresh ore.

IV. The bullion is produced as follows: The precipitation-boxes are cleaned up and the coarse zinc separated from the fine precipitate by screening in water; the precipitate is then treated with sulphuric acid to dissolve the fine zinc which it usually contains in considerable quantity. The residue is then washed, dried, melted in crucibles with the proper flux, and the bullion cast into bars for shipment to the mints. This method is at best, however, tedious and beset with many difficulties. It should never be attempted without the proper apparatus, which must always include an exhaust fan to remove the noxious gases evolved from the acid treatment. The dried precipitate is occasionally shipped direct to the large smelting and refining works, such as the Omaha and Grant, at Omaha, Nebraska. With small mills this may, on the whole, be the cheaper method to pursue. Sometimes the precipitate (freed from coarse zinc by screening) is dried and melted down in crucibles, producing, however, a very base bullion. This is the method invariably practiced in South Africa, where weight in ounces, and not quality of bullion, appears to be the desideratum. Experiments are now in progress looking towards the refining of the bullion and shipment of fine gold bars and silver residues from the cyanide mills; they show a tendency toward the best practice in this country.

Such is, in brief, the *modus operandi* of one of the most successful hydro-metallurgical methods for the economical treatment of medium-grade gold- and silver-ores. Any attempt to enumerate the ores amenable to cyanide treatment is (apart from its impracticability) entirely beyond the scope of this article; carefully conducted laboratory experiments should alone be the guide in every instance. When these experiments are successful, they can with certainty be followed with equally successful milling.

A first-class cyanide plant, complete in all its details, costs, for a capacity of 50 tons per day, about $25,000; for 100 tons daily capacity, about $40,000.

The cyanide process is often claimed to be an extremely simple one. With a properly constructed plant, efficient metallurgical supervision and skilled labor, it *is* as simple as any other well-managed metallurgical process; but in inexperienced hands it almost invariably proves to be profoundly complicated and extremely disappointing. Mills must be provided that will granulate the ore, chemists who understand the conditions necessary to effect a good extraction, and men who know how to charge tanks for lixiviation and keep filters in working order.

THEATER-BUILDING FOR AMERICAN CITIES.

By Dankmar Adler.

SECOND PAPER.

THE comfort of an audience and its enjoyment of a stage performance are largely affected by the arrangement and character of the seating. Here there is an ever-present conflict between the desire to get as many people into a given space and the wish to make them comfortable after they have been got there. Observation of existing conditions teaches that, if the audience is to be comfortable, the width of the seats should be from twenty inches upward and their distance from back to back from thirty-two or thirty-three inches upward, and that upon floors which have high steppings the distance from back to back should be greater than where the floor is more nearly level. Complicated mechanisms of folding chairs have always been a source of annoyance after the effect of their novelty or apparent ingenuity has worn away. Elaborate upholstery, unless of the very best quality, has also proved the cause of much vexation to owners and managers of theaters.

Aisles should be placed at small intervals, and in that case—if, say, only six seats apart—they need only be wide enough to permit two persons to walk abreast with comfort. Six aisles each three feet in width are better than three aisles each six feet wide, although the latter may be much more impressive.

A rational and consistent system of section- and seat-numbering is of great help to ticket-sellers, to ushers, and to the public, and is a safeguard against many annoyances in ticket-buying, in seat-finding, and in the enjoyment of the possession of the seat after it has been found. Of course every seat, including the seats in the upper gallery, should be numbered, and every ticket sold at the box-office should call for a definitely-designated seat.

The lighting of an auditorium, like almost every other point in theater-design, presents many conflicting conditions. During the performance, the house must not be too brilliantly lighted or its illumination will dim that of the stage, yet the house must be kept so well lighted that the play-bill may be easily read. When the curtain is down the illumination must be brilliant enough to allow display of rich toilets and to promote the sparkle of jewels, but it should not cast deep shadows, nor dazzle the eyes, and it should be all-pervading and equally diffused. As we are gaining experience in the use of the electric light, all this will become more and more easy of attainment.

Electric lamps can be applied almost anywhere, and can therefore be so arranged as to throw light of the right quantity and quality upon almost any object and yet still be themselves kept out of range of direct vision.

While these things are possible of attainment, they have not yet been attained. We are still too much hampered by the traditions of gas-lighting, and perhaps also to some extent by a practice, invented and introduced by myself, of using the incandescent electric lamp as a component part of the decoration of the theater. This practice seemed charming when it was new, and is still found so while the lights are turned low, and for the first few minutes after they are turned up, but soon after it becomes trying to even the strongest eyes and positively distressing to weak eyes. It may be that the solution of the problems encountered in the effort to obtain an effective and agreeable system of theater-lighting is to be found in the combination of the decorative effect of dimly-burning incandescent lamps with the reflected light of properly distributed and concealed arc-lamps, with which I experimented some years ago. Success was not attained in that instance, chiefly because of the jealousies of two different sets of contractors for electric-lighting. It may be well to add here that the lamps in halls and corridors should be kept burning full strength even when those in the auditorium are turned low, but that care must be exercised to prevent the hall and corridor lights from shining into the theater itself at such times. Great attention must be paid to the means of controlling and graduating the lights and in the arrangement of circuits and switches; and economy of current used by the janitors must not be lost sight of. The accessibility of the lamps for purposes of cleaning and renewal also demands the attention of the architect and may seriously affect certain features of the design.

The color decoration of a theater should be studied in connection with its illumination and also with a view to avoiding conflict in brilliancy and interest between auditorium and stage. The architect should not lose sight of the fact that the stage must be the center of attraction in every theater.

In the main, colors which act to any great extent as absorbents of light should be avoided, and those which, in contrast with the light absorbing tints may be called light reflectors, should be given the preference. Yet while the use of lighter tints tends to impart a festive and brilliant air to the house, they are apt to conflict with the toilets and complexions of many ladies in the audience ; and if darker tints are used the house will be somber and wanting in that festive brilliancy which should characterize the artistic treatment of a place of public amusement.

While it is possible to strike a happy mean between these divergent requirements, it has not often been done, and the architect who succeeds in so managing the illumination and decoration of a theater as to at once satisfy both the wearer of fine toilets and of beautiful complexions and the artistic sense, has abundant cause for self-congratulation.

The use of richly-modulated plastic surface ornament is an important aid to successful color decoration. It gives a rare interest to even the simplest scheme of color distribution by the introduction of modulations of light and shade, by the constant variations of perspective effects, and by the brilliancy of the protuberant points and edges as they catch and reflect the light. This interest may be still further enhanced by the use of carefully designed and modeled figure sculpture in low relief or even in moderately high relief.

The entrances and exits and all means of internal communication of every theater should be broad, commodious, and direct. So-called emergency-exits are of no value unless they are open every night, and then only when an active effort is made by the ushers at the close of every performance to induce people to use them. The tendency of an audience is to leave the house by the ways through which it has entered, and the use of emergency-exits will never be thought of by the transient theater-goer unless there is a large number of habitues of the house to lead the way, and these can only be taught to do so by the constant and unremitting efforts of the management. The English practice of having a separate entrance and a ticket-taker for each of many subdivisions of the house has the advantage of making the audience familiar with many means of exit and of thus preventing a rush to a single main entrance and exit as is the practice in the United States. The stairs, halls, and corridors should have a set of emergency lamps always kept burning while the house is in use, but having a source of supply and regulation independent from that of the auditorium and stage.

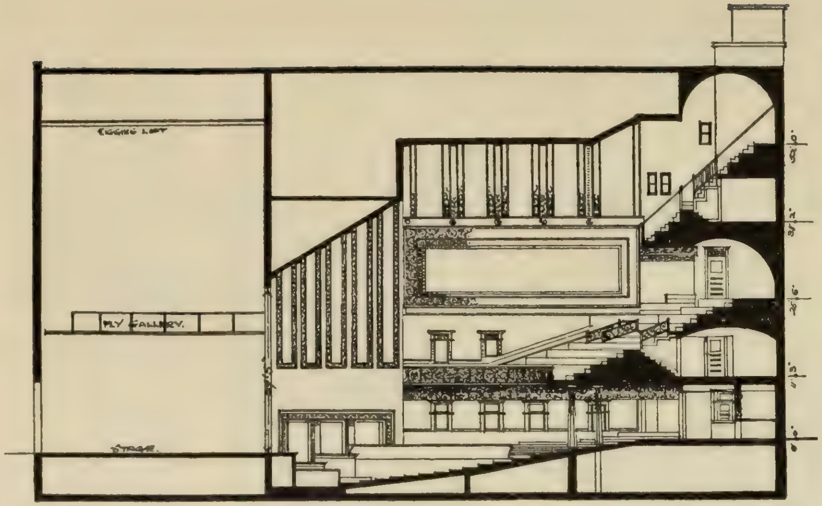
Real and popular success in heating and ventilating a theater is even more difficult of attainment than in its lighting and decoration. People consider a theater well ventilated if in warm weather they are kept very cool and in cold weather they are kept moderately warm, and their judgment is little if at all influenced by the extent to which the air is actually changed and renewed. The temperature which people consider respectively warm or cool varies by at least ten degrees in different individuals at the same time, and is subject to the same range in the same individual at different times under variations of mood and physical condition.

We meet at the outset, therefore, an insurmountable obstacle to the adoption of a generally satisfactory standard of temperature and are sure that, whichever standard we adopt, it will be unsatisfactory to many persons in the audience. But after a standard temperature has been determined upon, it is difficult even with the most perfect apparatus and under the most favorable conditions to maintain it. At whatever temperature the air is admitted into the house, contact with the lights and with the bodies of the people will quickly raise it. The brilliancy of the illumination and consequently its heat-radiating powers vary from time to time during the same performance and of course from play to play, while the sizes of audiences are subject to nightly change. Coincident with these changes are variations of external temperature and of barometric and hygrometric conditions of the atmosphere, as well as of wind direction and velocity and these variations of external conditions occur irregularly as to time, character, and extent, and sometimes run a gamut of changes during a single performance to the utter confounding of even the best managers and engineers.

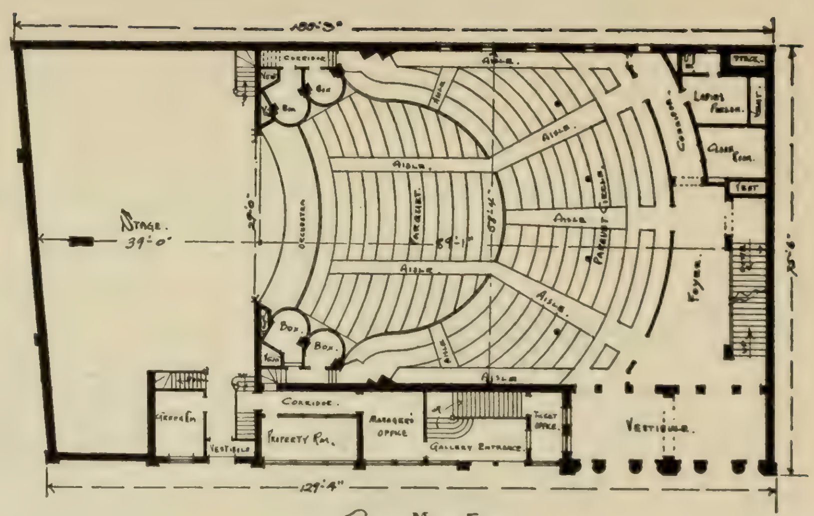
If a theater could be effectively sealed to all influx or efflux of air, except as it is introduced and removed by the ventilating apparatus, and if ingress and egress of audience and actors were effected through air-locks or through doors the use of which would not be permitted during the performance, it would be possible to maintain within its walls atmospheric conditions very closely approximating a fixed standard of temperature, pressure, and moisture. If also an audience could be so selected as to have it composed of people approximately of uniform physical and mental peculiarities, to which select audience the thermometric, barometric, and hygrometric standard of the theatre has been adapted, approximate success might be attained.

In designing and operating the heating and ventilating apparatus of a theater all thought of satisfying cranks and hypochondriacs must be abandoned. A standard temperature satisfactory to the average healthy human being must be determined upon, and adhered to as closely as possible.

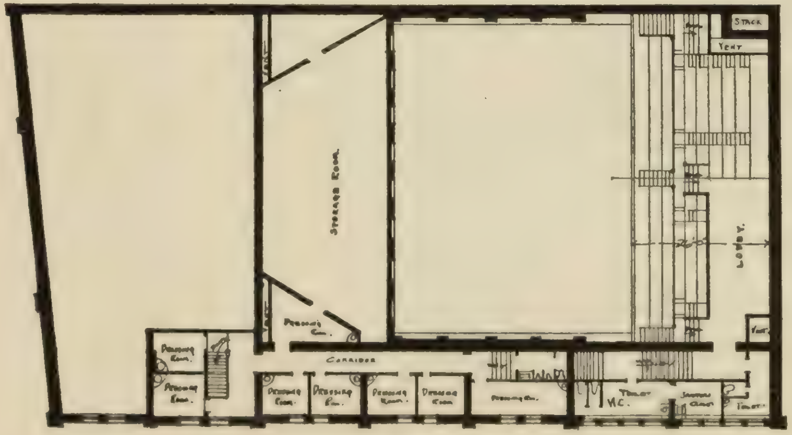
As ventilation through doors and windows is practicable only for small rooms, and then only in warm weather, the movement of the contained air by mechanical means becomes a necessity. But as the range of successful operation of mechanisms does not extend far beyond the conditions for which they have been designed, it becomes necessary to see to it, that the room to be ventilated has no means of communication with the outer air other than those which form part of the ventilating system. This banishes open windows entirely, and makes it desirable that there be inserted as many sets of doors between the street and the theater as it is possible to find room for. There should never be less than three sets of doors, and four or more would be better.



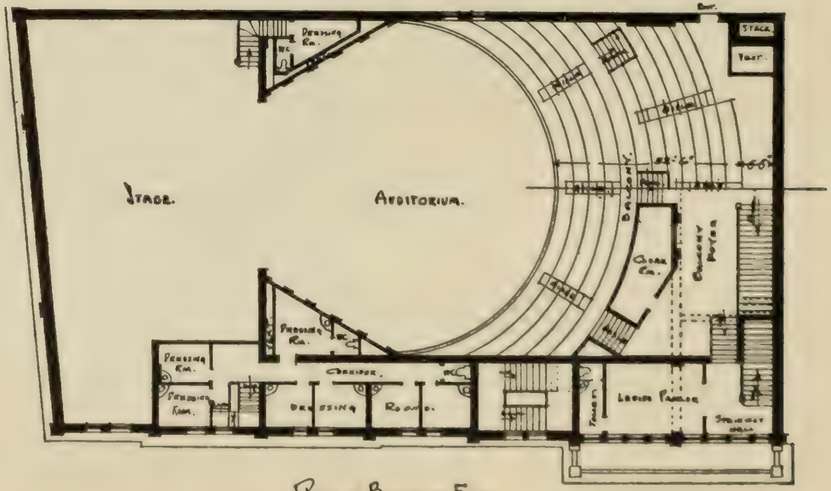
LONGITUDINAL SECTION.



PLAN OF MAIN FLOOR



PLAN OF GALLERY FLOOR



PLAN OF BALCONY FLOOR

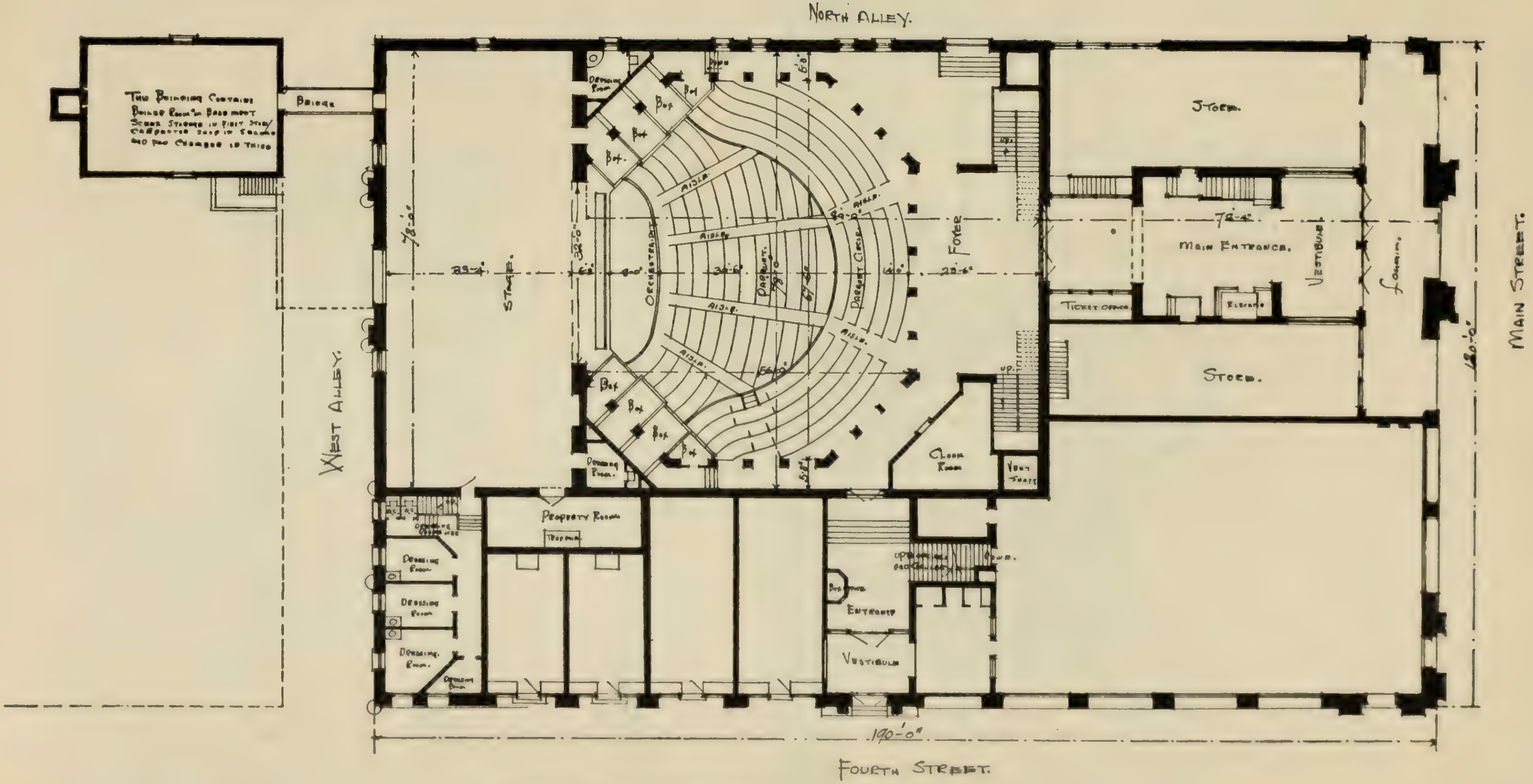
DEUTSCHES STADT THEATER, MILWAUKEE, WISCONSIN.

These doors should not be too near each other; we must minimize the likelihood of having them all open simultaneously. The vestibules or lobbies between the successive sets of doors should be well warmed, in order that the rushes of air, which will in spite of precautionary measures sometimes come into the auditorium, may not take the shape of cold drafts. If the house has windows or skylights, they should be double or triple, so as to prevent the precipitation of excessively cooled air into the room.

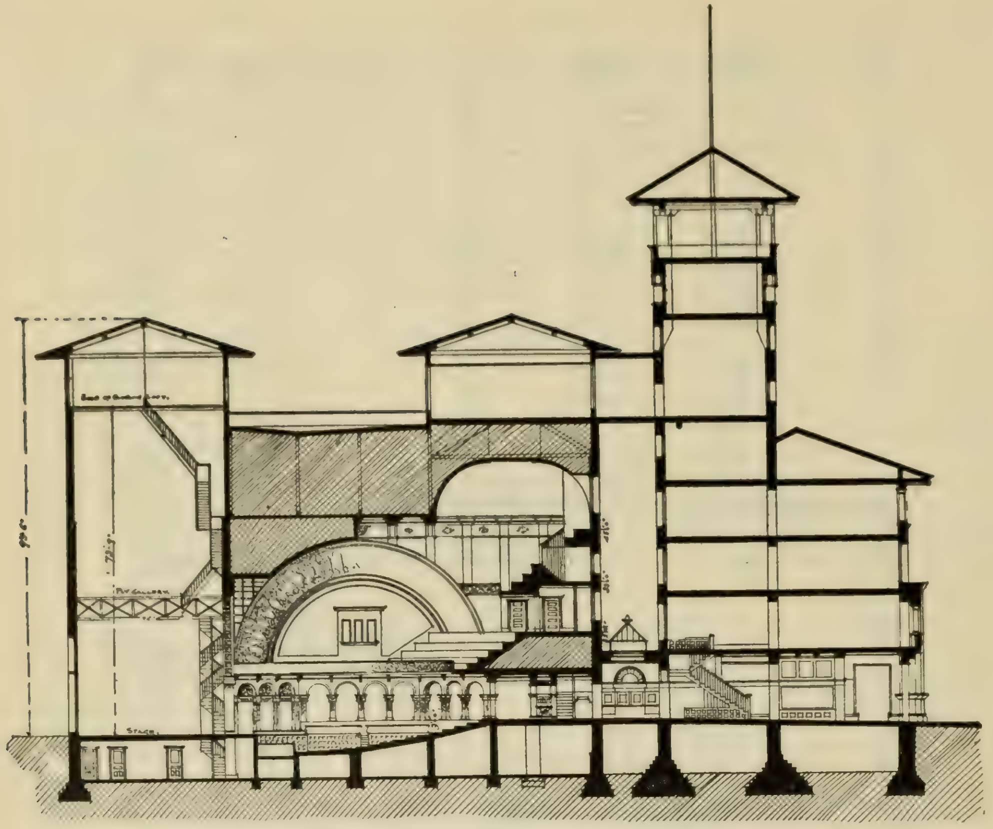
Having as far as possible eliminated possible elements of disturbance and interference, the actual work of ventilation begins. This involves the conveyance, to every part of the room, of fresh air in sufficient volumes for health and comfort, and the removal of a corresponding volume of air after it has performed its intended functions. The fresh-air supply should reach every person in the house and should be approximately constant in temperature, volume, and velocity, nor should its velocity ever be sufficiently great to make itself perceptible as a draft. To accomplish all of this, the ducts for both admission and removal of air must be very large and the openings from the ducts into the rooms quite numerous and very much diffused. Particular attention should be paid to the space under galleries and to all parts of the house which are apt to be used for "standing room," so as to be sure of a rapid movement of the air in these places. It is always well to admit fresh air to the stage and to all dressing-rooms, but while the curtain is down the air-supply to the stage should be reduced.

Before the advent of the electric light it was necessary to admit fresh air for the most part through the floors and to exhaust through the ceilings, a practice still much followed. Such air-inlet openings become receptacles for dust, the coolest air in the room is at one's feet, and the slightest excess in velocity of air movement is felt as a draft about one's ankles. Since the electric light has come into use it has become possible to admit the air at the ceilings and to exhaust it at the floor. This prevents the blowing back into the room of sweepings and places the feet of the audience within the warmest air in the house, but excessive velocity of the fresh air-supply is apt to be the source of serious discomfort to baldheaded men and bare-shouldered women, a difficulty which can be avoided only by extreme diffusion of air inlets and outlets and the prevention of disturbing air-currents from doors and windows.

Ordinary disk fans and pressure-blowers are the motors best adapted to the purpose of theater-ventilation and they may be driven by steam-engines or by electric motors. Their wheels should be very large and the propelling motors should be constructed so as to be capable of operation at varying speeds.



PUEBLO OPERA-HOUSE BUILDING—MAIN FLOOR.



PUEBLO OPERA-HOUSE BUILDING.
[Longitudinal Section.]

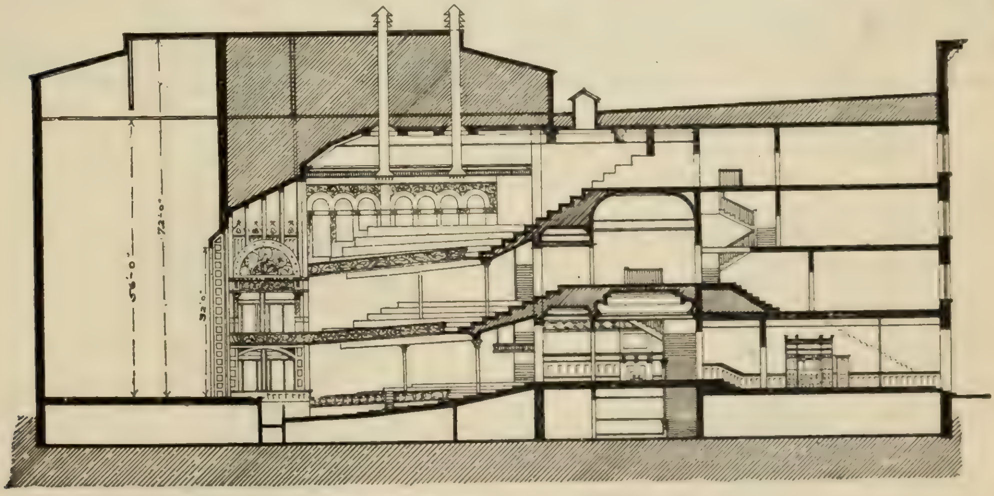
In smoky or dusty neighborhoods the air can be forced through a shower of water before it is driven into the building. This shower can be cooled with ice or brine in summer, by which means quite a reduction in temperature can be effected.

The temperature of the air forced into the house in winter can be regulated by turning the steam into a greater or less number of heating coils, through which coils the air passes before it enters the room. A further means of regulating the temperature of the fresh air is found in the use of a switch-damper, the position of which determines what proportion of air shall pass over the steam-coils and what shall pass into the house unwarmed. For the purpose of mixing the air of the two temperatures and sending it all into the room at a uniform temperature, these coils and dampers should be placed on the out-door side of the fan. All regulation of valves and dampers may be effected either by hand or by an automatic apparatus, the operation of which is governed by the temperature.

Control of the humidity of the air is easy when moisture must be added to maintain the established standard; but to reduce the atmospheric humidity is a very difficult and expensive matter, and, except to the slight degree possible of accomplishment by the agency of a very cold shower, requires a system of pipes in which a circulation of some freezing fluid is maintained.

When the electric light was first applied to the illumination of theaters, it was thought that danger from fire would be greatly diminished, and that a theater constructed with wood framing and lighted by electricity would be as safe as one of "fireproof construction" lighted by gas. Experience has demonstrated that the introduction of the electric current will not diminish the risk of fire, and that the use of combustible material in the structure of a theater is fraught with as much danger as before, and that there is as much reason as ever why theaters should be built entirely of incombustible materials.

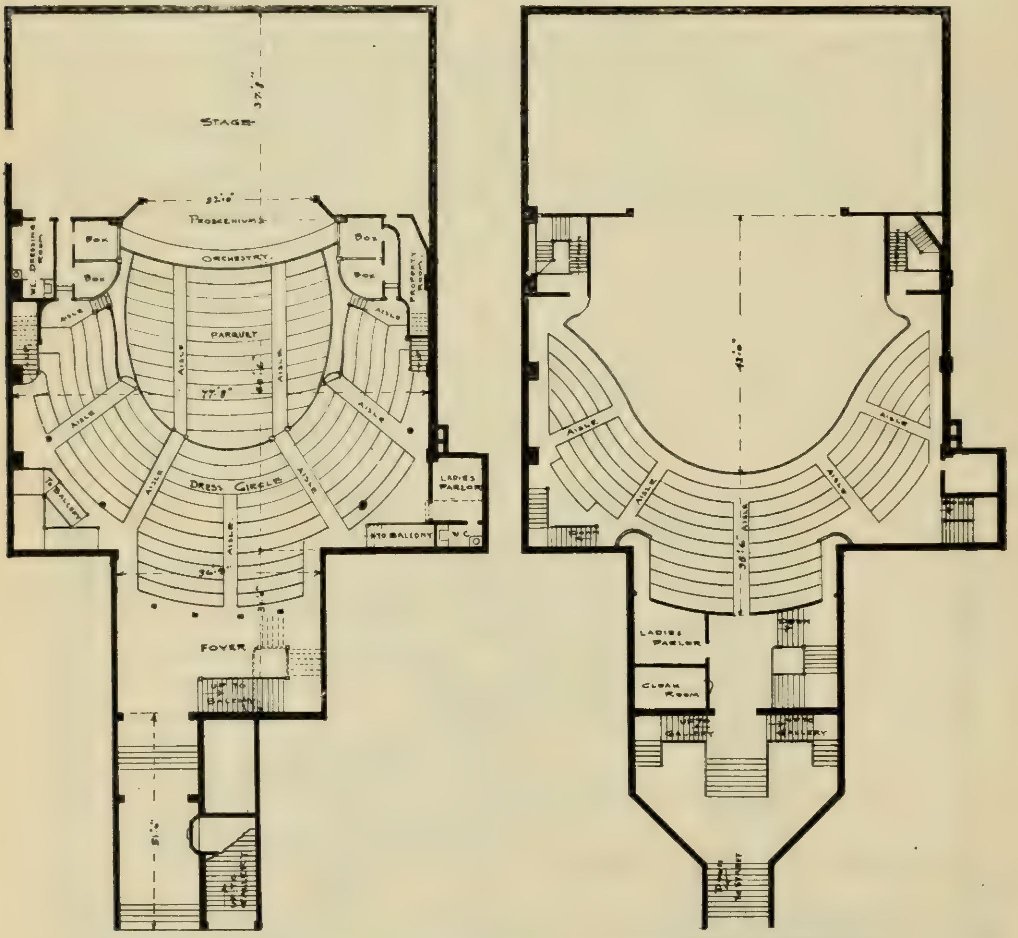
Of the many admirable systems of fireproof construction developed in modern building practice none is better adapted to the requirements and peculiarities of theater-construction than those which use for floor and ceiling construction a combination of rolled steel, metallic laths, concrete, and plaster. Upon the stage, however, the material must be confined to rolled steel beams for the main structural members and to flat iron or L or T iron for the floors of fly galleries and rigging loft. Wire cable can be used to a great extent for the support of drops, border lights, etc., thus confining the use of inflammable material to the heavy planks which, bolted to steel beams, form the stage floor; also to the properties, the drops, the borders, set pieces, etc., of the scenery, and the floors of the drops and bridges, the framework and guides of which may, however, be of metal. Experience has shown less actual permanent value than is claimed by their advocates, in the use of the various fireproof paints and compositions sometimes applied to the lighter and movable combustible parts



GRAND OPERA-HOUSE, CHICAGO.
[Longitudinal Section.]

of the stage equipments, for they are handled so often and so roughly, and are so frequently altered and patched, that much of this paint is rubbed, shaken off, or planed off very soon after its first application. A further difficulty, when the canvas is coated with a fire-resisting composition, is found in its deleterious effects upon the pigments used. Still it cannot be denied that these compositions are of some utility, and that for the stationary combustible material which may form part of the stage and its appointments their value is quite positive and permanent.

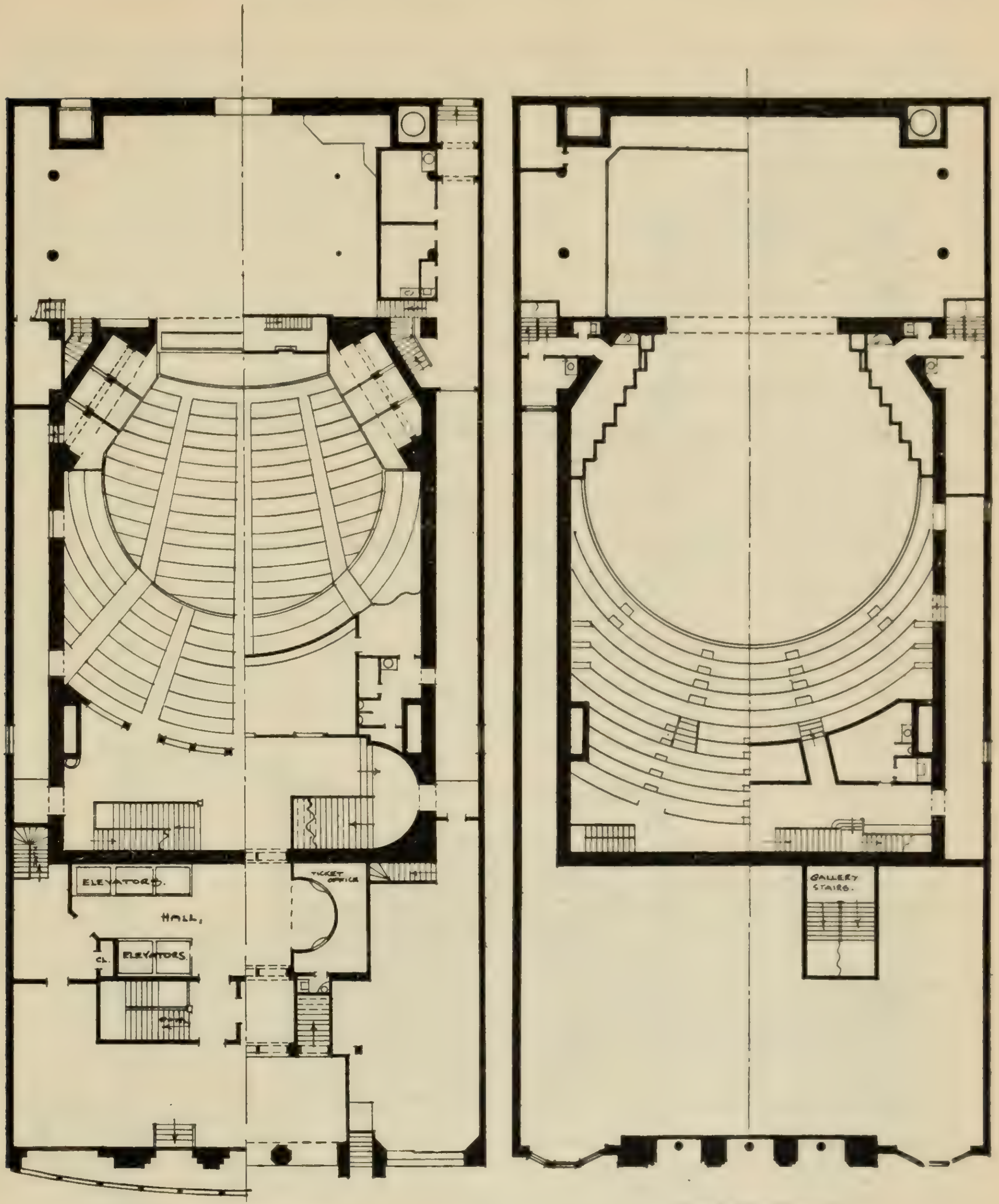
Returning now to the auditorium and the use of incombustible materials, it is well to remember that the use of hard and unyielding materials for forming enclosing surfaces must be avoided, and also to bear in mind the fact that plastering on metallic laths fastened to a light iron framework has demonstrated its value as a material possessing sufficient resonance for use in this connection. That stairs, corridor floors, walls, and support should be incombustible goes without



PLAN OF MAIN FLOOR

PLAN OF BALCONY

GRAND OPERA-HOUSE, CHICAGO.



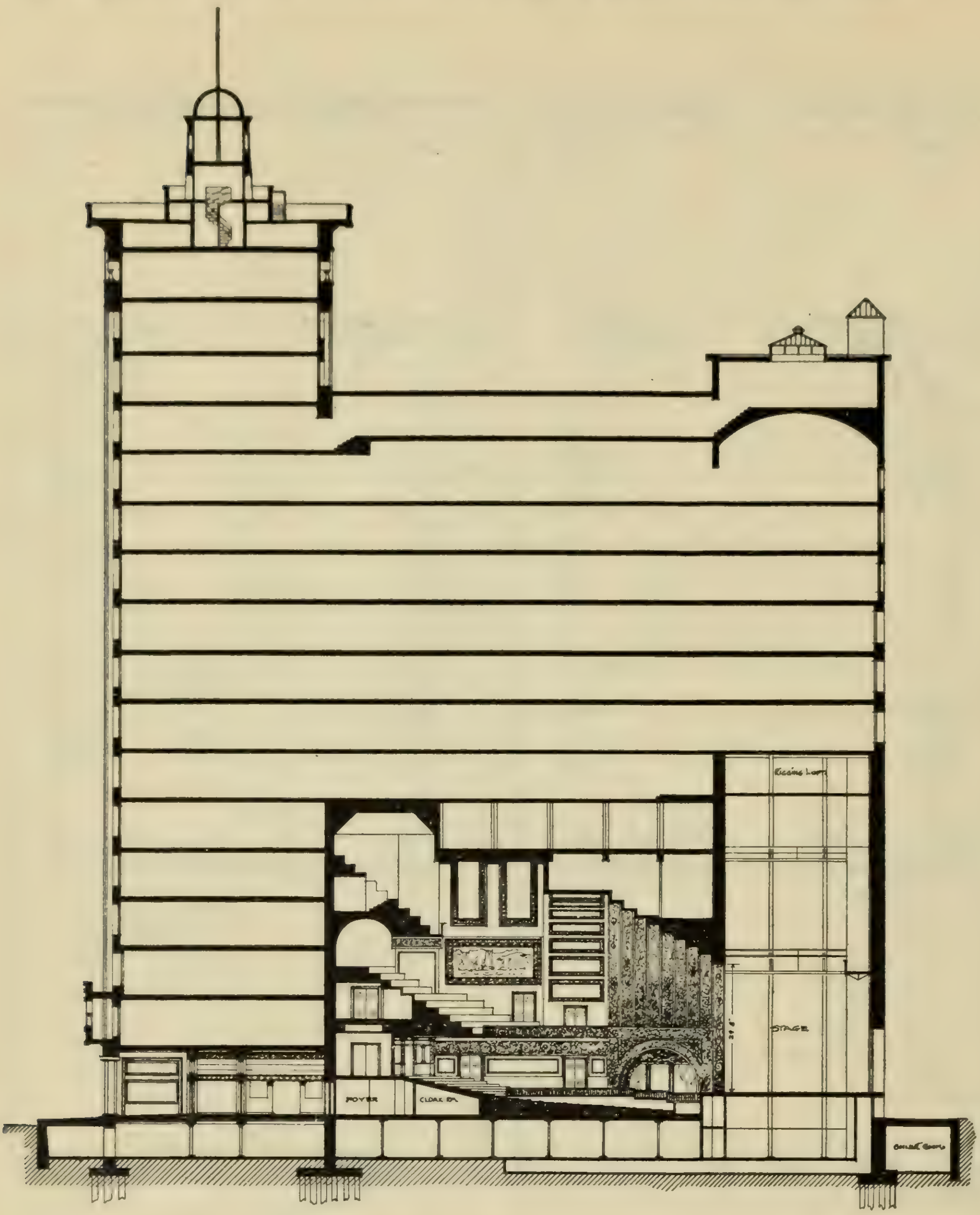
FIRST AND SECOND FLOORS.

THIRD AND FOURTH FLOORS.

-PLAN-OF- BALCONY-

SCHILLER THEATER, CHICAGO.

saying. Wherever possible, girder and cantilever constructions should be used in preference to pillars for supporting galleries, so that the lines of sight in the lower parts of the auditorium may be unobstructed. The roof girders and trusses as well as girders, beams, and posts generally should be fireproofed. Where there is danger of knocking off the fireproofing material of pillars, on the stage, in store-rooms, etc., there should be an outer protecting shell of sheet iron. There should be a special contrivance for holding the fireproofing on the



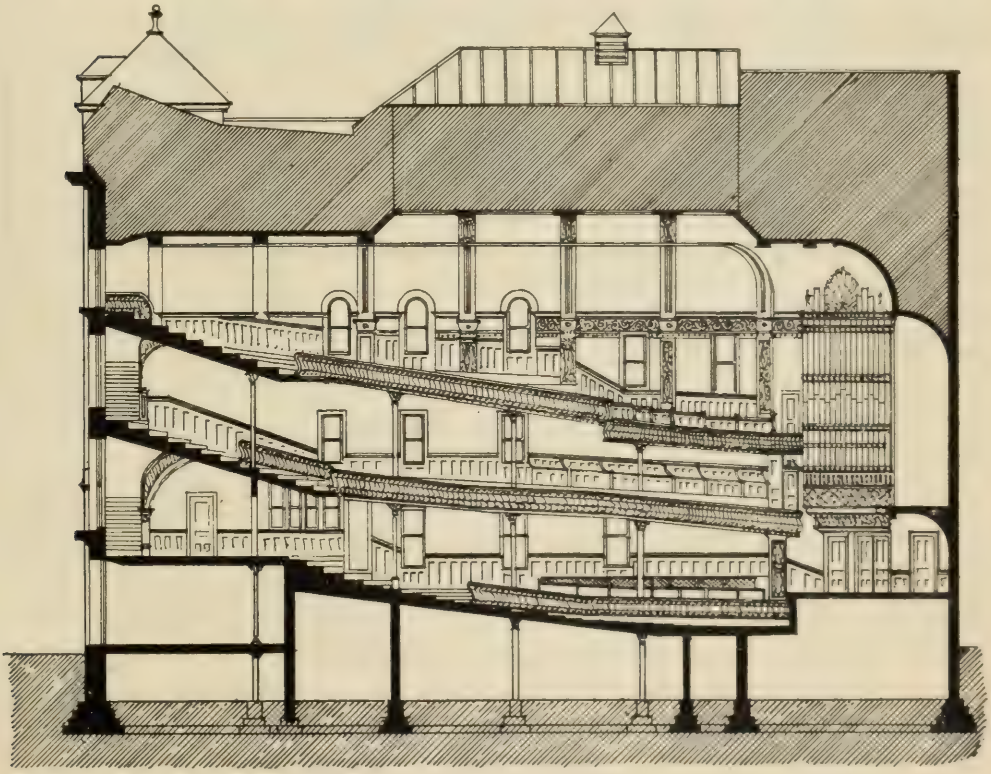
SCHILLER THEATER, CHICAGO.
[Longitudinal Section.]

trusses, girders, etc., in such manner that a powerful stream of water from a steam fire-engine may not force it off and expose the metal to the flames.

Equally important with fireproof construction are precautionary measures for checking incipient fires. Stand-pipes should be extended to every space in or about which a fire might originate. Reels of hose should be in readiness at all of these places. The stand-pipes should be connected with the steam pumping-apparatus of the building and should have openings on all adjacent streets and alleys convenient for connection with steam fire-engines. Chemical fire-extinguishers should be made and maintained as part of the stage equipment. Very large smoke-escape ducts, having suitable dampers controlled from the prompter's stand, should be incorporated with the equipment of every stage. If the manager will institute frequent fire-drills, participated in by all of the theater employés, so that each person employed by the house will know what to do in case of fire and will from force of habit do the right thing at the right time, danger from destructive fires in theaters will have been greatly reduced.

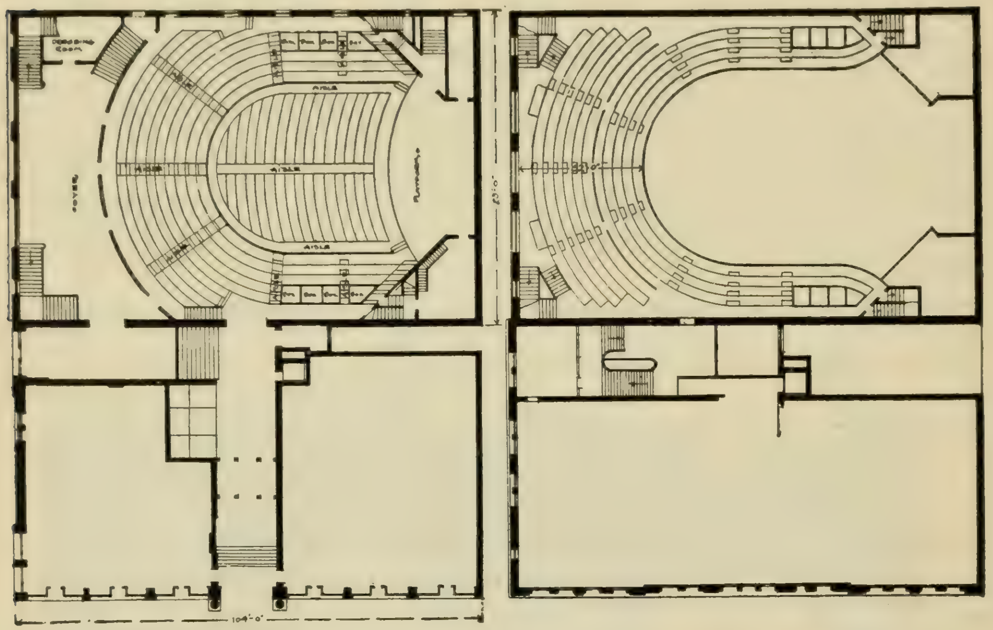
Large foyers and lobbies add greatly to the safety and comfort of an audience and may also be made valuable adjuncts to a comprehensive scheme of ventilation. In Europe the foyers, lobbies, and promenades often occupy much more space than the auditorium. American theater-owners and managers would do well to consider whether space given up to such purposes might not cause so great an increase in attendance at their houses as to yield good interest on the outlay for additional ground, building, equipment, and maintenance. A necessary sequence of adequate foyer and lobby would be better dressing-room and wardrobe accommodations than is ordinarily found in American theaters.

Experience teaches that Americans are always ready to make use of



CENTRAL MUSIC HALL, CHICAGO.
[Longitudinal Section.]

every opportunity given them for raising their standards of comfort and of luxury, and in their home life, their travels, and their public amusements, they justify Mr. Pullman's saying that "nothing is too good for the American people." The general introduction of great foyers, parlors, dressing-rooms, and wardrooms will tend to give theater attendance the character of a festive social function and may add to the box-office receipts the contributions of the participants in these functions, whose presence in gala attire will again be an attraction, for many who are not themselves "in the swim," but who delight in observing their more fortunate or more frivolous fellow-beings of the fashionable world. Then the foyer, as well as the stage, would interest and charm the audience and the intervals between the acts would become as entertaining as the stage performance itself. And perhaps the street costume of the ladies and the high hat would yield to a drawing-room toilet and a less aggressive head-dress.



[Plan of Main Floor] [Plan of Balcony]

CENTRAL MUSIC-HALL, CHICAGO.

But this paper is already longer than was intended, and yet it has not exhausted its subject, or accomplished more than to skim over the surface of those of its phases which have been treated. Its chief purpose has been to call attention to the principal factors which enter into the design and construction of a good theater for an American city. It has been assumed that, from the owners and manager's standpoint, a theater is not necessarily simply a stage and auditorium built and maintained at a minimum of expense, for the purpose of packing within its walls a maximum number of people, but that stage and auditorium should be designed and constructed with the one end in view, of attracting larger audiences by giving entertainments of the best possible character to people comfortably seated amid healthful, artistic and luxurious surroundings, and protected as far as possible against danger from fire, panic, drafts, or other causes.

From the point of view of the architect, the theater, as treated in this article, is not to be an opportunity for proving how unfit he is to build a theater by designing, in strict accordance with the tenets of any "style," a great proscenium, a grand entrance and staircase, of providing a ceiling surface for the development of a great allegorical painting, and leaving the rest to the stage-carpenter and a miscellaneous aggregation of engineers and "specialists," but that a theater is an organic whole, which in its totality and in its details must be conceived and built with but one purpose in view,—that of providing a stage upon which plays can be adequately presented, and an auditorium in which every person can in comfort hear and see all the stage presentations, in which access and egress to and from seats is commodious and safe, and from which actual danger from fire or panic has been practically eliminated. Whatever the architect knows of historic style and of plastic and pictorial art, should not endeavor to assert itself independently and in defiance of practical considerations and requirements, but should be coördinated and blended with these, so that the practical phases of the problem attain an artistic solution and that the work as a whole becomes a harmonious artistic creation from which all evidences and indications of the effort to harmonize apparently incongruous and conflicting requirements have been eliminated.

If architects and laymen who have read this article recognize that success in theater-building is not a matter of chance, and that the means for its attainment are not shrouded in mystery, but involve merely the application of the same mental processes which are the fundamental conditions of success in every undertaking, I shall feel amply rewarded for writing these pages, even if my readers think that, if what I have written is all which an alleged expert in theater-building can tell them about matters concerning which he and a few fellow adepts were supposed to possess exclusive knowledge, then any one who observes and thinks, and knows how to act under the guidance of close observation and clear and incisive thought, may join the ranks of those experts and be their equal or superior.

THE PRESENT CONDITION OF THE PANAMA CANAL.

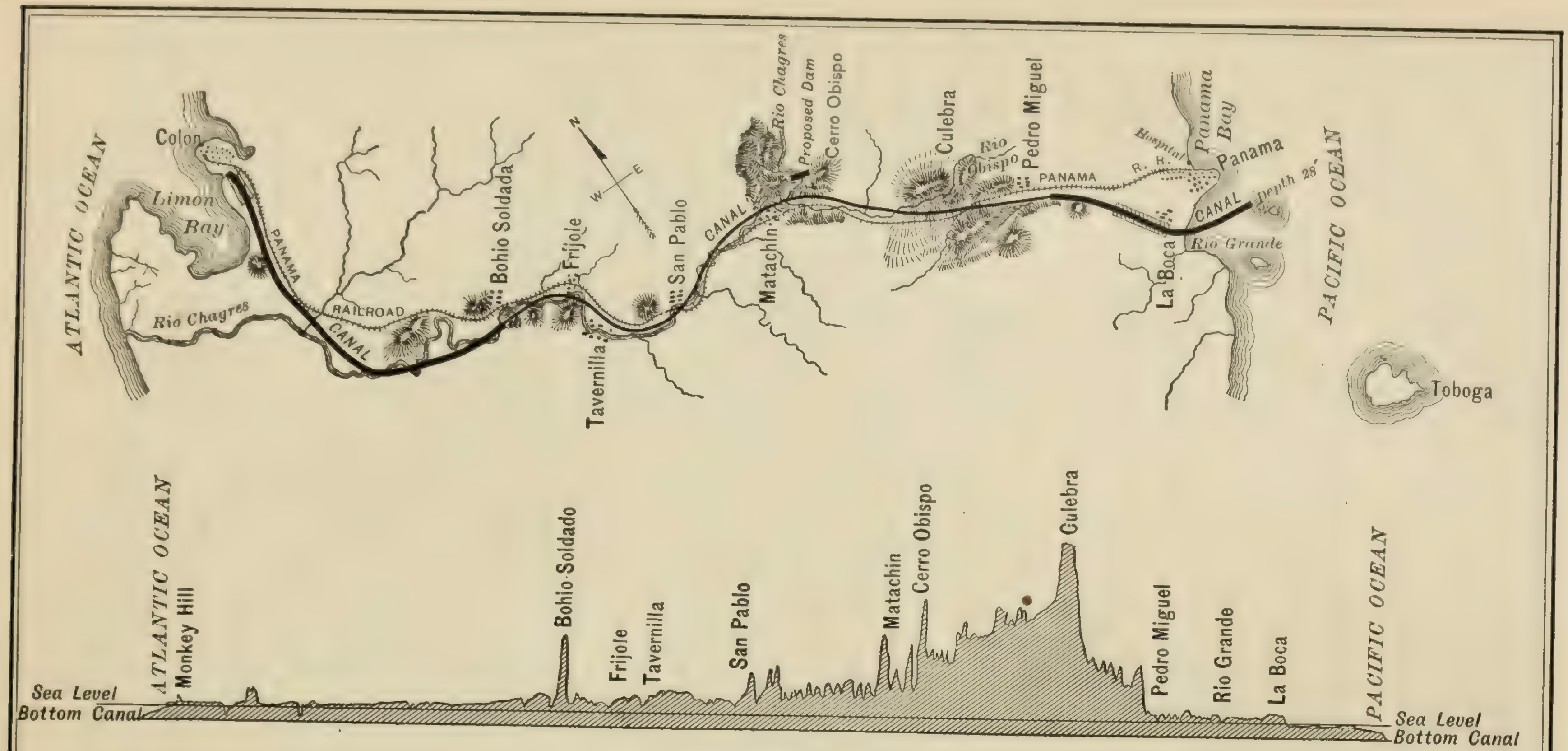
By Oscar A. F. Saabye.

THE Panama canal has been before the public so many years and has been written about so fully that the subject might seem to have lost all interest to magazine readers, especially since financial failure has been the result of the undertaking. But since serious efforts seem to be in progress for the reorganization of the construction company, with a view to completing the canal, there may be some reason for a practising civil engineer to offer a few facts respecting the present condition of the work already done, based upon recent personal observations.

It cannot be denied that the Panama canal, to-day, is practically a failure, financially considered, but this result has been reached through dishonesty, bad financial management, and worse engineering supervision. Hence this failure does not necessarily reflect upon the feasibility or practicability of the project as an engineering work, nor upon the selection of this route as a practical solution of the problem of a connection between the Atlantic and the Pacific oceans. If the Panama Canal Company, which is still in existence,—with the work already done, with its immense resources on hand, in form of machinery, buildings, dredges, barges, steamers, etc., for continued construction,—had sufficient funds to finish the work, under reorganized, good, honest management and competent engineering superintendence, the Panama canal would undoubtedly within the next decade prove to be not only the best adapted, but probably the most economical, solution of the long-standing question of a shipway from the Pacific to the Atlantic via the isthmus.

While returning recently from an engineering engagement in Ecuador, I was compelled to stop over in Panama eight or ten days to await steamer connection in order to reach the United States. Naturally, out of professional interest, I utilized this opportunity for an examination of the Panama canal, as it appears to-day, the result of which is this article. It may be remarked, however, that the figures used here are taken from the calculations of M. de Lesseps's engineers, and they are given for what they may be worth, as the time at my disposal did not permit any separate reliable calculations to be made.

As the canal has been surveyed and laid out between Colon, on the Atlantic, and Panama, on the Pacific side, it will have a total



Location and Profile
OF THE
PANAMA CANAL.

Completed Portions of the Canal, at either end, indicated by heavier lines.

E. F. Fisk, N. Y.

length of 46.7 miles. Owing to the peculiar formation of Panama bay, the Pacific end is really the eastern terminus of the canal. The canal runs through the valley of the Rio Chagres and almost parallel to the Panama railway until within a few miles of Panama. Its distance from the railway varies from a few hundred feet to about half a mile. The proposed general width of the canal is 72 feet at the bottom and 100 feet at the water's level, with the exception of the section between San Pablo and Pedro Miguel, where the respective widths, as proposed, would be 78 feet bottom and 102 feet at the level of the water. The navigable depth is to be from 28 to 29 feet, and all curves of the canal to be constructed with a radius of not less than 8000 feet. At the mouth of the canal, at La Boca, about three miles southwest of Panama, it is proposed to build a basin, or kind of harbor, about 5000 feet long by about 400 feet wide, for vessels to await transport, and at Tavernilla, about midway between the Atlantic and Pacific, another to allow ships to pass each other.

The elevations along the canal route are about as follows: From Colon to Frijole, a distance of eighteen to twenty miles, the ground rises almost uniformly to 25 or 30 feet, with the exception of a short distance at Bohio Soldado, where the elevation reaches 160 to 170 feet above sea-level. Between Frijole and Matachin, about eleven miles distant, the elevations vary from 50 to 115 feet. At Matachin is another short *loma* (hill) of about 155 to 165 feet elevation. From Matachin to Culebra, a distance of about six miles, the elevations run from 90 to 260 feet, until they reach, at Culebra, the highest point on the whole route. Here the *cerro* is about 323 feet above sea-level for a distance of nearly 1000 feet. From Culebra the ground falls again uniformly to the Pacific, with an elevation of about 15 feet at the junction with the Rio Grande.

According to surveys and observations made by the engineers of the Panama railway, during its construction, the mean level of the Pacific is from .14 to .75 of a foot over that of the Atlantic. The highest tide at Panama is 21.30 feet; and the lowest 7.94; the highest spring tide in the Pacific over the highest spring tide of the Atlantic is 10.12 feet; the mean high tide of the Pacific over that of the Atlantic is 6.49 feet. These conditions would, if the canal is constructed as a tide-water connection, enable vessels to make the passage on one tide of six hours' duration.

The French engineers have calculated the total canal excavation necessary at something like 157,200,000 cubic yards, of which about 24,000,000 cubic yards are contained in the Culebra cut. This amount, I understand, includes also extra work outside the canal proper,—for instance, laterals for draining the Rio Chagres, etc. Of this total excavation I judged that about from three-eighths to one-half—or about 70,000,000 cubic yards—has been done. Of the total length of the canal, about one-half, including about fifteen miles on the Atlantic side, has been finished or very nearly so, and there is water in this portion on both sides, its depth varying from 18 to 23 feet. The finished part is in comparatively good condition. Besides the work already done, the canal company has on hand, distributed at both terminals and at convenient points along the canal route, an immense stock of machinery, tools, dredges, barges, steamers, tugboats, and materials for continued construction. At Panama, La Boca, and Colon, as well as along the canal, are numerous buildings, large and small, for offices, workshops, storehouses, and warehouses, and for lodging and boarding the men who were employed on the work. The finished work, as well as all the machinery, tools, materials, buildings, etc., are well taken care of and looked after. The canal company employs 100 uniformed policemen, besides numerous watchmen, machinists, and others, whose sole duty consists in watching the canal and looking after needed repairs of plant and care of materials. In fact, the work and the whole plant is in such a condition, so far as I could ascertain, that renewed construction could be taken up and carried to a finish at any time it is desired to do so, after the company's finances will permit. In this connection it may be mentioned that the canal company has built, and still partly maintains, a hospital in Panama which in magnitude, comfort, equipments, and general appointments excels some of our best American hospitals, and, in fact, could give them good points in hospital management. This hospital, which is in charge of the French Order of Sisters of Mercy, is situated about 1½ miles north of Panama, on beautifully laid out grounds, at an elevation of 300 to 400 feet above sea level, giving a magnificent view of the superb bay at Panama and the surrounding country. It consists of sixty or seventy large, roomy, and airy buildings, and contains inside the grounds its own waterworks, drainage system, slaughter-houses, dairy, drugstores, etc., so that in case of any epidemic the hospital could be shut entirely out from communication with the low-lying city of Panama. Patients unable to pay are treated free in the same manner as those who are able to pay for their accommodations. At Colon there is a smaller hospital under similar management.

Now as to the feasibility of finishing the canal, and the difficulties to be overcome. The latter naturally resolve themselves into two classes, relating to the engineering and the financial features. As far as I could see, the engineering plans seem feasible and the obstacles such as might readily be surmounted. The chief difficulties encountered are: (1) The prevention of the Rio Chagres from overflooding its banks during high waters and flooding the canal, and (2) the Culebra cut.

The Rio Chagres is a mountain stream, having its headwaters in the Andes, which the canal crosses at Culebra. Like all mountain streams, it is treacherous. In the dry season and under ordinary circumstances it discharges about 500 cubic feet of water per second. In the rainy part of the year, which lasts from six to eight months, during which time daily heavy rainstorms occur, the discharge of water per second rises to 20,000 cubic feet or more; it has even been known to reach the enormous quantity of 65,000 cubic feet per second, with a rise of the water to 45 feet above its normal level. The watershed drained by the Chagres, as far as it can influence the canal, is not very large or of much importance. The extreme high waters are caused by the heavy tropical rains. In order to protect the canal from such an enormous inflood of water from the river, which of course would soon destroy it and its usefulness, two plans have been proposed by the French engineers. The first one is to dam the Chagres at such a point as will retain the water, during rainstorms, long enough to permit the discharge to be controlled to its normal flow. The other is to change and enlarge the channels of the river, so that the water, during the high floods, will be discharged at a distance far enough away from the canal to secure its safety. Neither of these plans, so far as I understand, has been based upon accurate surveys or calculations. Upon a casual examination, the first one—damming the Chagres—seems to me the most feasible and probably the least costly.

After passing Matachin the river turns in an easterly direction, leaving the canal, and at Gamboa passes between two mountains,—Cerro Obispo and Cerro Santa Cruz. Here it is proposed to construct the dam, which would probably be about 5000 feet long and 150 to 160 feet high. An outlet of the water from the dam by a tunnel through Cerro Azul, to the left of Cerro Santa Cruz, is also proposed. The storage-capacity of the reservoir behind the dam is claimed by M. de Lesseps's engineers to be somewhat like 105,900,000,000 cubic feet. The cost of the dam is estimated at about $1,600,000. To build such a dam, with its tunnel-outlet and laterals, probably may at first seem an enormous undertaking. Its construction in point of engineering would, I fully believe, offer no insurmountable difficulties.

The Culebra cut is situated about nine miles from Panama. Its total length is about two miles, and the highest elevation, as already noted, is 323 feet above the sea-level. It has lately been proposed to tunnel through the highest portion. A French engineer has proposed recently to construct a lock on either side of the cut, so that it would only have to be excavated to a depth of 75 to 80 feet. This latter plan would undoubtedly save much time and labor and probably also decrease the cost. But it would deprive the canal of one of the principal points in favor of its construction,—that of making it a tide-water connection. The cut would require about 24,000,000 cubic yards of excavation, of which the greater part is rock. Nearly all of the excavated stuff could be utilized in the construction of the dam across the Chagres. I do not see any great difficulty in taking out the whole cut, as originally proposed, aside from the time and labor it requires, and even that would be materially less than anticipated by the French engineers if the work were conducted properly and honestly. Some work has already been done in the cut, but none at the dam besides some preliminary examinations.

It has also been argued that the question of labor, as well as the unhealthful conditions on the isthmus, would prove a serious difficulty to overcome in finishing the canal. Undoubtedly the French, while they pursued the work, had much trouble in regard to laborers. The chief cause of this was that the French contractors picked up many of their laborers from the slums of all countries. These men were unaccustomed to this kind of work, and also to the climate. In many cases they did not desire work, but came out to the isthmus simply for the sake of adventure. Their past lives and environment made them an easy prey to disease and they consequently increased the death-rate, always heavy among the unacclimated in a tropical clime. If the work were to be taken up to-day, I believe that any number of native laborers could easily be had, if not from the isthmus itself, from the surrounding South and Central American republics, and from Jamaica, etc. These laborers, mostly negroes, are strong, healthy, and good-natured men, accustomed to work in the tropics. Their chief fault is laziness, but, properly managed, they would soon get over that and prove to be very efficient and cheap workmen. There has been no yellow fever on the isthmus for several years, but only sporadic cases of intermittent fever. As the work on the sections of the canal through the swamps and marshes has been finished, it is not supposed by the natives that any great amount of illness would be caused by the renewal of work on higher ground.

As to the financial question I must, as an engineer, hold aloof from saying anything about the probable cost of finishing the canal. It would simply be guesswork with the time at my disposal, and management by guesswork has already proved a costly feature in the history of the Panama canal. It should be remembered, however, in this connection, that although vast sums of money have been expended, and much of it uselessly, about half of the canal is finished, or very nearly so, and a large, valuable, and well-kept construction-plant, machinery, materials, and buildings, etc., are on the place ready for work. Before the work is taken up anew it is an essential necessity that the present company should be thoroughly reorganized, under good and honest management. It is also absolutely necessary to have an accurate examination, survey, and estimate made, by competent engineers of the work already done and what remains to be done, as well as of the stock, machinery, and materials on hand, upon which to base future financial calculations.

The watchword of the new management should be efficiency and honesty. The French management was rather "a white elephant" upon the company's hands—more elaborate than useful. All the officers necessary on the isthmus would be a competent, honest chief engineer, with an equally competent engineering staff, and an efficient, honest general business manager.

In conclusion it may not be amiss to indulge in a few words of comparison between the Panama canal and Nicaragua canal, the latter of which also seems to be in sore distress just now. The supporters of the latter canal project claim chiefly, as to its superiority over the former, that it is more feasible as an engineering feature and cheaper to construct ; that the healthfulness of the surrounding country is better than on the isthmus, and that better and cheaper labor can be obtained there. I have not personally been at Nicaragua, but I have seen the Panama canal as it is to day. At the latter place there is a full-equipped plant ready for renewed work, and there is already a railway running parallel to and within a short distance of the canal for all necessary transport. There is a splendid and accessible harbor at either terminus. All the buildings necessary for the work are there, as well as excellently-equipped hospitals ready for service. The canal is only forty-seven miles between oceans, and, if finished as proposed, as a tidewater connection, would allow vessels to pass through in about six hours. About half of it is finished. The remaining work, it is true, is heavy, but it is perfectly feasible and can be done.

Now at Nicaragua the inland connection between oceans, according to the surveys made, would be 170 miles long, of which there are 40.3 miles of new work to be constructed. The remainder is through the Rio San Juan and Lake Nicaragua, in both of which considerable work would also have to be done in order to make them safely navigable. There is no harbor of consequence at either terminus. The country is barren and without means of transportation for supplies. There is no construction-plant, and no buildings worth consideration. The difference of mean level between the two oceans is here greater than at Panama. The Nicaragua canal is to be constructed with locks, and the passage between oceans would be much longer.

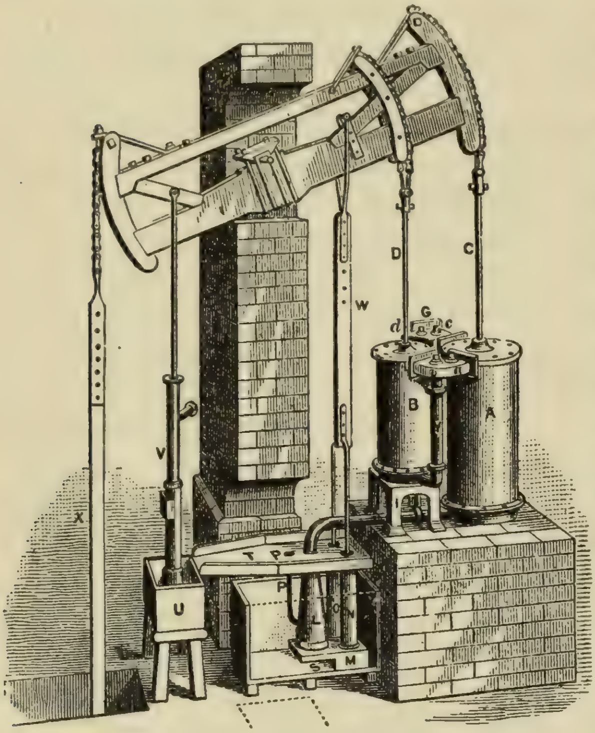
USE OF COMPOUND STATIONARY ENGINES.

By Robert H. Thurston, LL.D.,

Director of Sibley College, Cornell University.

A "COMPOUND ENGINE" is one in which steam is worked in two cylinders successively,—*en cascade*, as the French express it, or in series, as the electrical engineer would say. The "high-pressure cylinder," taking its steam directly from the boiler and expanding it to a moderate degree, rejecting it at a still available pressure for further utilization, it is received into the "low-pressure cylinder" and, there expanding to a minimum terminal pressure, is finally exhausted into the condenser or into the air. The compound engine is of the class "multiple-cylinder engines," in which any number of cylinders may be thus worked in series, and in which this number is greater as pressures increase. Thus the compound engine usually is employed at pressures not far from 100 pounds per square inch; the "triple-expansion engine" (three cylinders *en cascade*) is adopted at 125 to 180 pounds, and the "quadruple-expansion" (with its four cylinders in series) at 200 pounds and over; expansion occurring, usually, to the extent of two or two-and-a-half times, and occasionally three or four, in each cylinder. The larger the number of cylinders, as a rule, the less the ratio of expansion adopted for either. The expansion commonly terminates at about five pounds pressure, by gage, in non-condensing engines, and six or eight pounds above a vacuum in condensing engines, in the best practice; the total ratio of expansion thus ranging from about five to ten in the former and between fifteen and thirty in the latter, for extremes of pressure.

The object of "compounding" is the reduction of the internal (thermal) wastes of the steam-engine, which constitute the most serious of the heat-losses in all modern forms of engine and amount to a considerable fraction—sometimes one-half, often one-quarter—of all the heat, steam, and fuel demanded by the machine. This now familiar waste, known to the engineer as "cylinder-condensation," occurs through the alternate heating and cooling of the cylinder-walls, as they are exposed first to the high temperature of the entering steam, and then to the cooling influence of the exhaust,—absorbing heat from the steam, storing it during the stroke of the piston, only to discharge it, unutilized, into the condenser or into the atmosphere. The greater the range of temperature and of pressure in the cylinder, the more serious this waste. The higher the initial pressure and the ratio of total expansion, the more difficult it is, for this reason, to secure those economies which, in a purely thermodynamic operation, would follow the adoption of high pressures and corresponding expansion-ratios. In fact, so rapidly do these wastes increase with increasing expansion that, in the single cylinder, a point is reached at a very moderate ratio at which the gains are completely extinguished by more than equal exaggeration of "initial condensation" of the steam. Many an inventor has been disappointed and immense amounts of money have been lost in the vain endeavor to attain that economy in the operation of the engine by a "short cut-off" which its thermodynamic theory shows to be within reach if thermal wastes can be extinguished, and dynamic losses reduced to a minimum. Dividing the expansion among a number of cylinders in series, the range of temperature and the consequent waste is greatly diminished in each, —in fact, nearly in proportion, in well-designed engines, to the number of cylinders,—and the steam condensed in the first is reëvaporated at exit and supplies the demand for waste in the second, and thus through the series; the final result being the loss, in the whole machine, with its large ratio of expansion, of only the equivalent, substantially, of the waste of a single cylinder with its small expansion. Thus, were steam worked in a single engine, condensing at ten pounds terminal pressure, from an initial pressure of 150 pounds, the condensation, if the cylinder were unjacketed, would probably be not less than half of all the steam sent over from the boiler. In the compound engine, unjacketed, this would be reduced to something like 25 per cent., and in the triple-expansion and quadruple engines, respectively, to perhaps 20 and 15 per cent. With jacketed engines, these figures would be still further reduced. The low ratios of expan-

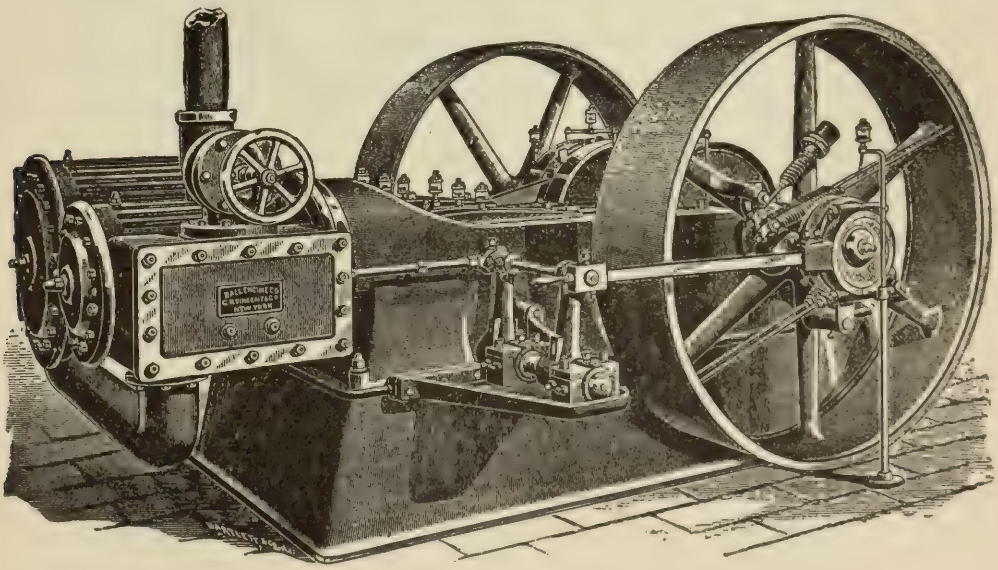


HORNBLOWER'S COMPOUND ENGINE, 1781.

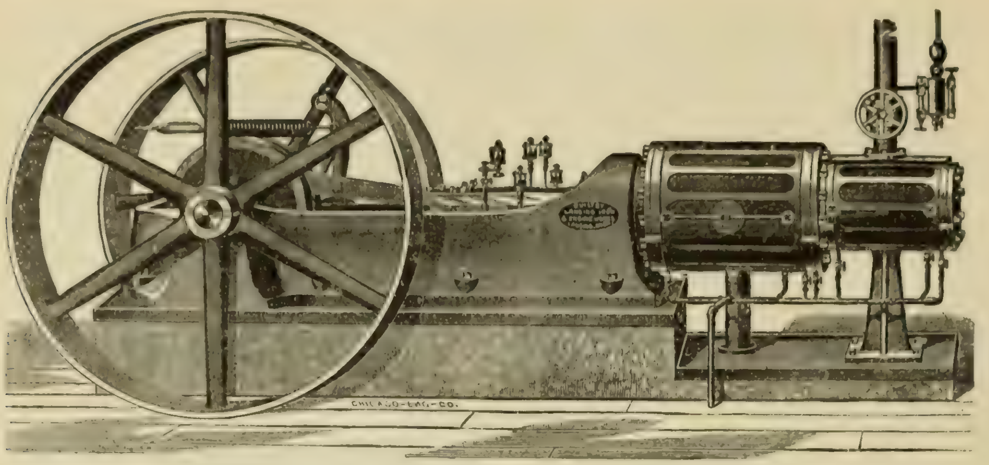
[*A*, the large or low-pressure cylinder; *B*, the small or high-pressure cylinder; *C* and *D* the piston rods; *X*, the pump-rod.]

sion in the cylinders and the cascade action thus enable the engineer to secure a gain which in most cases well repays the trouble, costs, and complication of the multiple-cylinder engine. There always comes a point, however, in this progress of costs with gains of economy, when the gain is more than compensated by the increased costs ; and it often proves undesirable to use the most economical types. Cases are frequently met in which high economy cannot be afforded, as a matter of finance. These cases occur where fuel is cheap and engines are costly to build and to keep in repair, and where, as in passing from the triple to the quadruple machine, the gain by the change is comparatively small.

The compound engine, like many another invention, although only recently brought into common use and made successful, is a century old. It was, when first devised, in advance of the age and it failed, as do so many inventions, for that reason. James Watt is often said to have been the inventor of the steam-engine ; he is called, with more reason, the author of all the minor details of the modern engine, and the compound engine is one of those modifications which, by his friends, is attributed to his genius. The fact is that the steam-engine of modern type is the invention of Newcomen, who was the first to introduce a train of mechanism in which the engine proper was set apart from the apparatus which it was constructed to drive. Watt gave to the engine of Newcomen the separate condenser, the first satisfactory forms of "self-acting" valve-gear, the governor, the steam-jacket, and other details, and applied it to turning a shaft as well as to the operation of pumps. The compound engine was first actually built and introduced in real work by Hornblower about 1781 ; but Watt secured a verdict



"CROSS" COMPOUND ENGINE.

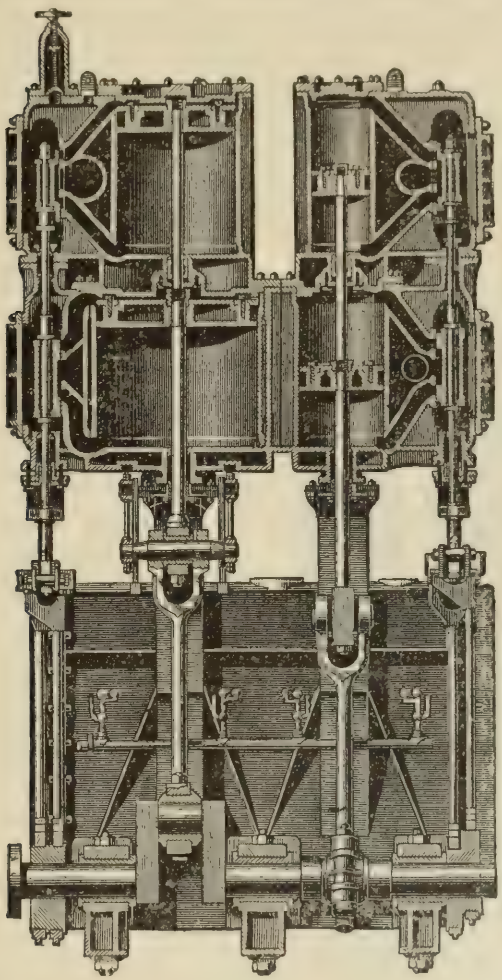


TANDEM COMPOUND ENGINE.

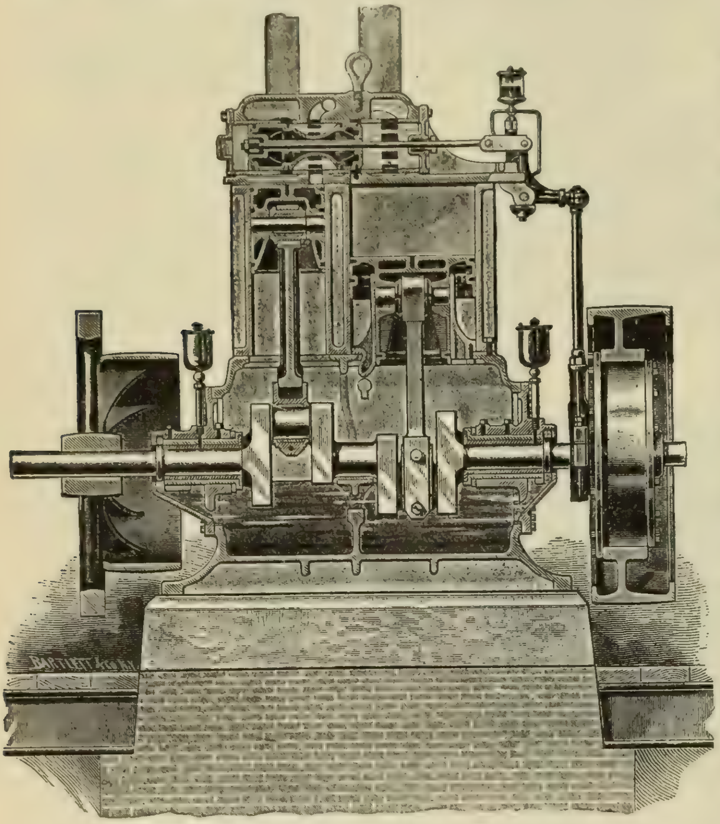
against him for infringement of earlier patents, and obtained an injunction which promptly stopped the construction of the new machine. In the course of this trial and in his communications to his friends on the subject, Watt claims the idea of compounding as his own and calls the machine his "double engine." Neither Watt nor Hornblower, however, seems to have really understood the theory of the engine, or its method of reduction of internal wastes of heat and steam, but thought it mainly useful in permitting larger expansion than was practicable in the simple engine with equable motion; variations of pressure on the piston, as expansion progresses, giving correspondingly irregular speed of piston and of fly-wheel, notwithstanding the weight of the latter.

During the controversy which arose at this time, Professor Robison enunciated a principle which has been since stated by Rankine, in almost the same words: "So far as the theoretical action of the steam on the piston is concerned, it is immaterial whether the expansion takes place in one cylinder or in two or more cylinders." The real advantages appear only when steam-pressures and ratios of expansion are comparatively great, and consist in an improved effect due to suppression, in large part, of cylinder condensation, and a more regular action than can be had with equal expansion in a single cylinder. Incidentally, also, it is possible to reduce the variation of stresses on the running parts of the engine by compounding.

The engine dropped out of sight for the time, but it was again brought out with higher steam-pressures, and made slow progress from the beginning of the century until about 1850, when the success of Randolph & Elder in marine-engine construction gave it a permanent place. It has since constantly gained upon the older type, its superiority constantly becoming more evident and marked as steam-pressures rise. In Watt's time, the engines of that great builder and engineer were found to be superior in economy to those of Hornblower. To-day the compound and higher types of multiple-cylinder engine often excel the rival simple engine in economy of steam by 25 to 30 per cent., and, in some cases, very much more; while still further gain in fuel is secured in consequence of the smaller demand upon the boiler for steam and consequent improvement of efficiency in the latter.


QUADRUPLE-EXPANSION ENGINE.

The relative values of the several types of condensing engine at various ratios of expansion from a common initial high pressure are best exhibited by a diagram such as is given in the diagram. The lowest curve exhibits the varying efficiency of the simple, ideal, high-pressure engine, as measured in British thermal units or in pounds of steam per horse-power per hour, assuming 1000 thermal units expended per pound, no extra-thermodynamic wastes occurring. The next curve shows the costs, similarly measured, when friction, or the dynamic waste, is introduced; the difference between the two being the cost of power required to overcome that friction. The highest full-line curve measures total costs in the same way, when heat-wastes are taken into the account; the difference in magnitudes of ordinates of the second and the last curve being proportional to the expenditure compelled by those wastes. Midway between these last curves is shown another curve which, taking compounding as an expedient for substantially halving the internal wastes, shows the varying economy of the double-expansion engine. Still another curve divides the space measuring the cylinder-condensation loss by three, and exhibits the gain due to the use of three cylinders *en cascade;* while still another curve, just below the latter, represents the action of the quadruple-expansion engine, in which the wastes are taken as one-fourth those of the simple machine, the dynamic wastes being taken as equal for all. Above each curve is a dotted line which is obtained by superposing upon the total costs of the engine the proportional expenditures on account of interest, taxes, insurance, and other treasurer's accounts. The whole system is to be taken simply as illustrative, and as substantially right for the particular cases here considered. The method can be applied to any case in which the data can be secured, giving three or four points in either curve. But the data for the special case in hand should always, if possible, be obtained. Where this is impracticable, the engineer may often approximate the required curves and results by reference to familiar cases of approximately similar character.



SINGLE-ACTING COMPOUND ENGINE.

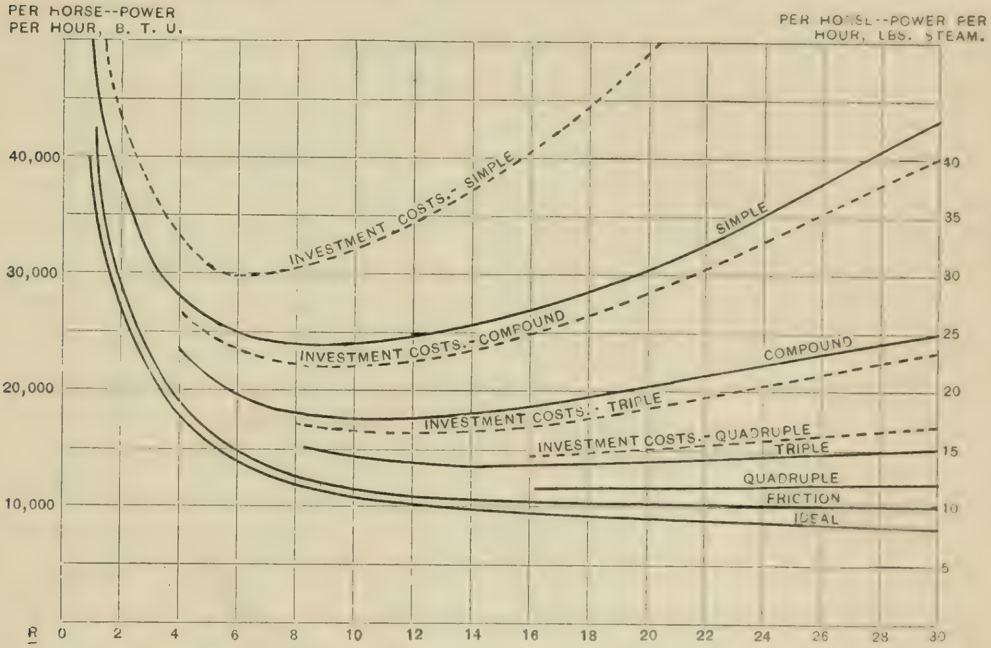
The striking and essential deductions to be drawn from such an investigation will be seen to be the following:

I. The expenditure of steam, in the ideal case, decreases constantly, with increasing expansion, without limit, in the case of the condensing engine with zero back-pressure, and up to the point at which the terminal pressure becomes coincident with the back-pressure in the non-condensing engine; ranging from about forty down to eight pounds of steam per horse-power per hour with from one to thirty expansions, in this case.

II. The friction wastes become an increasing tax upon the engine, with increasing ratios of expansion, and with consequent decrease of power obtained from the given machine. Ultimately, the engine would be unable to overcome its own friction, and it is at once obvious that, this waste alone being introduced, a point is somewhere passed at which costs reach a minimum, and beyond which expansion ceases to be advantageous.

III. Thermal wastes being added, to obtain the curve of efficiency for the simple engine, we find these wastes to be, also, an increasing tax and in rapid progression, giving a minimum ordinate at a very early point in the curve.

Expansion, in this case, instead of giving continual, unlimited gain, finds an early limit, and at a comparatively low efficiency, as measured by the heat, steam, and fuel consumed. For the simple engine of ordinary construction, this limit is often found at a ratio of two-and-a-half, or sometimes even less. This limitation of the maximum efficiency of the older form of engine by the occurrence of internal wastes is seen to be something extraordinary. In condensing engines, where, otherwise, the best ratio of expansion would be the quotient of initial by back pressure, the ideal engine would have a ratio of about fifty, in many cases, where about three would represent the limit, in wasteful engines, and five or six in the best ordinary work with unjacketed engines. The non-condensing engine, with 100 pounds gage-pressure would, in the ideal case, expand about seven times; while the real engine seldom has an effective expansion exceeding about four, and it is often as low as three.



COMPARATIVE EFFICIENCY OF ENGINES.

IV. The multiple-cylinder engine adds to the cost of the engine, increases the external wastes, and the friction, other things equal, but divides the internal, and principal, extra-thermodynamic wastes in the proportion, roughly, of the number of cylinders in series. It gives, consequently, higher practicable ratios of expansion and enhances the efficiency of the machine and its economy of heat, steam, and fuel, in the best contemporary stationary-engine practice, in something like the following proportion :

	POUNDS PER HORSE-POWER PER HOUR.	
	Steam.	Fuel.
Simple engine, best work, condensing, jacketed engine-cylinders	25	2.8
Compound engine, similarly designed	18	2.
Triple-expansion	14	1.5
Quadruple-expansion	12	1.25

The number of cylinders in series, in practice, is generally about one for each fifty or sixty pounds steam-pressure ; the compound employing about 100 pounds, the triple-expansion, 150 or 160, and the quadruple coming in at about 200. The gain is thus due, in part, to increased pressure, as well as higher expansion ; but the simple engine cannot take advantage of the higher pressures to increase the ratio of expansion in any approximation to that of the ideal case, as can the multiple-cylinder machine, because of the exaggeration of its internal wastes. Non-condensing engines, of either type, demand higher pressures than the condensing, in consequence of their high back-pressure.

V. The efficiency of the engine being known, together with its expenditure of steam, heat, and fuel, the choice of type is properly determined by the costs of construction, installation, and operation.

With coal at $1 per ton, for example, it is probable that the simple engine would be, on the whole, the cheapest type ; and it is doubtful whether, in any such cases, the user could afford to pay for engines of higher economy ; but with fuel at $5 a ton, the compound would be, on the whole, cheaper ; with higher figures or at sea, where every pound of coal displaces a pound of paying freight and every ton a passenger, and where coal must be consumed to transport coal, the triple-expansion engine, and even the quadruple-engine, finds economical application. The reduced cost of the boiler-plant, in the multiple-engine system, comes in as an important element of economy of operation, not only as reducing interest accounts on first cost, but as lessening the repair-account, always large on boilers. This reduced expenditure on boilers often more than offsets the extra cost of engines, and makes the multiple-cylinder plant financially superior to the simple, where, otherwise, the latter would be wisely adopted.

A careful study of the finances of the case will show a curious series of compensations in this respect ; the more wasteful engine having such superiority in its first-cost and interest accounts as to sometimes fully, and always in large part, compensate its deficiency on fuel account. These differences become still less when the whole financial problem is studied and the fuel account is thus made a single item among many, in the comparison. On the whole, and under average ordinary conditions of operation, the compound engine is the most economical type. Where coal is very cheap, the simple engine is better; where fuel is very costly, the triple-expansion is best. The larger the amount of power demanded, the more can we afford to approach the ideal by refining the design and construction of engine, and by the adoption of the higher types. The more continuously the engine is worked, also, the more perfect can we afford to make it. In a flour-mill, running continuously night and day, the triple-expansion would usually pay handsomely; while in other establishments, working, say, eight hours a day, the compound would usually be best. Where an engine is attached to a single heavy tool, as often is the case in rolling-mills, or where, as on a yacht, it is in operation during a comparatively small portion of the working day, the simple engine with a hard-driven boiler, is best probably in all cases. But the saving in cost of fuel and reduced size and cost of boiler, taken together, may, in the rolling-mill be found to make the multiple-cylinder engine the more desirable. The fact is that the decision must depend, in every case, upon a financial study of the case in hand, and this should be made by an expert.*

Engines of the classes above indicated cost, ready for work, in ordinary times, $20, $30, $40, and $50 per horse-power at standard ratings, and their boilers, set and piped, about $18, $15, $13, and $12 per engine-horse-power, respectively; buildings and accessories cost about $12, $10, $9, and $8. The cost of the horse-power per annum at ten hours a day, and with coal at $5 per ton, exclusive of attendance, and inclusive of interest and repair accounts, ranges from $20 to $16, $12, and $10 for average cases, or about $1 per year, per pound of fuel used per horse-power for fuel alone, or a total of about $35, $33, $30, and $28. Coal at $2 per ton will reduce these figures about twenty-five per cent Costs or rents of buildings and other incidentals, may bring up the interest and other accounts in individual cases, and changing market rates of engines, boilers, fuel, and accessories may change the whole account in such manner as to lead to different final conclusions; but the principles involved and the usual conditions are fairly illustrated in the above discussion. Cheap coal and high prices of material and labor make the uneconomical engine best; opposite conditions make the more economical, but costly, engine desirable.

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* Dr. Charles E. Emery has made a number of interesting studies of this kind, for the latest and most complete of which see Transactions American Institute of Electrical Engineers, 1893, or Thurston's "Manual of the Steam-Engine," fifth edition, Vol. II, page 819. For a study of the principles involved, see "Manual," Vol. I, chapter VII. R. H. T.

Evidently those industries will be most benefited by the introduction of the multiple-cylinder engines which are most dependent upon the supply of power by means of the steam-engine as the prime motor, and those which are situated at points remote from the fuel-supplies and main lines of transportation, where, consequently, costs of fuel are excessive. Low costs of construction and high costs of coal, in combination, give highest value to the more perfect type of engine; but the locations are of limited area in which the gain by their use will not compensate for their extra cost. Those industries which continuously employ steam-power throughout the twenty-four hours can profit best by the highest types of multiple-cylinder engine; those in which, as in rolling-mills, the demand for power is very intermittent, will gain least, and may find the simple engine on the whole preferable. Thus a flour-mill at Minneapolis and a rolling-mill at Pittsburgh may each do best by adopting a practice exactly opposite that of the other. Those establishments requiring least power will profit least by the purchase of a compound engine. On the one hand, the gain in economy is greatest with smallest and cheapest engines; on the other hand, the value of the total saving of fuel is of less proportional consequence in the business, and first costs constitute a larger item in the proportion. The limit can only be determined for each case when every figure is available; but probably almost any ten-horse engine will pay for compounding under familiar conditions of the market and outside the areas of cheap fuel. The multiple-expansion engine, like every other engine, should be cared for by a good engineer who is also a skilled mechanic; but it does not necessarily demand more care or skill than the best simple machine, as, for example, a good Corliss or Greene engine.

Where power is very variable, to answer the requirements of an extremely variable load, the compound engine has usually the advantage of less loss of economy than the simple engine; although, where non-condensing and too large for its work, the wastes due to extreme expansion, beyond the point at which the terminal pressure on the expansion-line of the low-pressure cylinder falls below the back-pressure line, may sometimes prove so enormous as to make such proportions of compound engine vastly less economical than the simple engine properly proportioned for the same place. Within this limit the simple engine loses more than the other forms with extreme variations of load. Regulation, another essential point, may be made as perfect in the one as in the other; neither should vary more than 1 per cent. between no load and full load, and both should be steady, however sudden the change. In consequence of the gradual establishment of these facts and principles, the multiple-cylinder engine is now rapidly displacing the simple engine throughout the world, and wherever economy of fuel is important.

Economy of fuel in the production of steam-power is a matter of far greater importance than is commonly realized, not simply as an element of finance, but also and mainly because of its bearing upon the welfare and comfort of the race. Civilization is to-day largely dependent upon steam-power, without which we must inevitably relapse into barbarism. The comfort of the most enlightened portion of the human race is dependent upon the use of fuel in temperate and cold climates, which means wherever civilization can flourish most completely and perfectly. But we have only a limited supply of fuel upon which to draw, and at the present rate of consumption we shall in a short time, as geologists reckon, entirely exhaust every known source of heat for power, and of warmth for the preservation of our families. The anthracite district of Pennsylvania, for example, is supplying to-day something like 50,000,000 tons of coal each year, and the bituminous mines over 100,000,000 tons. Adding to this rate only a moderate increase of demand, it is estimated that another century will see the whole anthracite deposit completely consumed. Our grandchildren and our great-grandchildren will be deprived of this essential element of comfort, if not of existence. The bituminous coal-fields are more extensive and will last longer; but Great Britain already sees approaching the end of her supremacy as a manufacturing country, and the continent of Europe will for a time take her markets, only, in turn, to be impoverished and destroyed in precisely the same manner. The United States must, in time, trace the same course, and the world, however great the as yet undiscovered or unmeasured deposits of coal and of oil which, in Asia, Africa, and other countries, remain untouched, must some time suffer from the complete exhaustion of all its supplies of fuel. The human race must then retreat to the tropics and retrograde into comparative barbarism unless other sources of heat and power can be found and utilized.* This ultimate and apparently inevitable fate can only be deferred, not averted; and the principal ameliorating condition must be the reduction of the quantity of fuel demanded by our heat-engines. This will occur to a moderate degree through the processes which have been above described; but it still seems likely that we must hope for some radical change in our methods of production and application of dynamic energy if we are to secure any very great modification of the period intervening between us and the time of Macaulay's New Zealander—who may prove to be the last of the race.

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* Berthelot anticipates the ultimate employment of the interior heat of the earth by boring wells to depths of thousands of feet.

MAIN ENTRANCE, ANTWERP EXHIBITION.

THE INTERNATIONAL EXHIBITION AT ANTWERP.

By Edmund Mitchell.

WHEN the men of Chicago set about building their World's Fair City on the shores of Lake Michigan, they freely declared their intention, not only of surpassing all preceding efforts of the kind, but also of setting a standard that would never again be attained by any international exhibition to be held within the lifetime of the present generation. That the retrospective part of this bold program was more than amply fulfilled, the voice of public opinion in every country has allowed. That the prospective portion is quite likely of accomplishment, a visit to the Antwerp Exposition of 1894 will tend to make most men believe. The contrast, both as regards broad general effects and minor points of detail is a most remarkable one ; and there can be no disputing the fact that the first of the World's Fair successors is running its course in the deep shadow of eclipse. It is not a mere question of magnitude ; the land of the Liliputians was just as intensely interesting to Captain Gulliver as the land of the Brobdingnagians. At the same time, the very first glimpse of the Antwerp Exposition buildings shows how much of the charm of the White City was due to broad acres and to wide expanse of waters. At Antwerp there is no Peristyle, with vast inland sea shimmering in the sunshine beyond its classic columns ; there are no lagoons, with swiftly darting electric launches and lazily progressing Venetian gondolas ; there is no Wooded Island with log cabin and Hooden Temple peeping from out a wealth of flower and foliage. The exquisite landscape effects, which were possible only in a wide demesne, at Antwerp are wholly absent. The result has followed that architectural achievement has been hardly attempted. At Chicago, almost without exception, every building in the grounds was a thing of beauty by itself ; and the general plan, which from the first had been kept fixedly in view, insured harmonious grouping, with the result that the scene as a whole was one of surpassing loveliness. At Antwerp, with everything "cribbed, cabined, and confined," there is simply a huddling together of shed-like structures, whose continuity alone helps to mask their ugliness. The central dome facing the main entrance is the only portion of the buildings where anything approaching to artistic effort has been made. As will be seen from the accompanying illustration, the result is not unsuccessful, although the palm still rests, beyond doubt or cavil, with the beautifully designed and exquisitely proportioned Administration building at Chicago, which was not, as here, a mere façade, but had to stand the supreme test of isolation.

However, it may be granted that architectural effect is not the be-all and the end-all of an international exposition. In this respect Chicago soared to a flight which those responsible for succeeding undertakings of the kind may not consider themselves bound to emulate. An exhibition has to be judged on its merits as a thoroughly representative and well-arranged display of the products of the world and the handiwork of man in divers lands. Passing from the exterior to the interior of the Antwerp Exposition, and without any preconceived notion of lauding the United States at the expense of Belgium, I am at once struck with a second most glaring contrast between the two exhibitions. The magnificent system of classification which Chicago gave to the world has been lost sight of, and the old, effete geographical plan has been blindly followed. The result is that any one desiring to study a subject, or subjects, in which he may be specially interested is at the very outset hopelessly gravelled. Classification in the proper sense of the word there is none. There is no mining section, no transportation section, no electricity section ; everything is jumbled together solely according to the country of production, so that a magnificent trophy of German ironwork is juxtaposed to a display of Japanese china, a butter-churn is next to a stand of French millinery, and agricultural products, or mineral ores have to be ferreted out in a score of odd corners. The only attempts made at grouping are with machinery for which a supply of motive power is necessary and with models of steamers from celebrated ship-building yards. It will be remembered that when the administration of the Chicago World's Fair adopted its system of classifying exhibits, there was a loud protest from more than one country against the proposal, on the ground that it would break up the exhibits and render impossible an effective display of the resources, industries, and wealth of any single nation. The Chicago directorate stood firm, and the contrast between their Fair and that now being held at Antwerp adds another proof, were such proof required, of the wisdom of their decision. At Chicago it was possible, with the minimum of inconvenience and the maximum of efficiency, to follow along each line of enterprise in every country of the world. Even the casual observer came away with a fairly full and coherent idea of wool-growing in many lands, of the lessons to be learned from competitors in dairying productions, of the utilization of machinery in a score of industries, of the mighty part played by transportation in the economy of modern life, and so on. At Antwerp while the student of any special subject is beset with difficulties, the saunterer, although he may see many things of utility and many things of beauty, cannot possibly institute comparisons; he cannot grasp general principles, and confusion of mind is the only result. At Chicago, the youngest child who walked through the Electricity building had indelibly printed upon his brain an object-lesson of what the new practical science is accomplishing and is likely to accomplish in almost every department of human enterprise. At Antwerp, so scattered are the electrical exhibits, he will probably leave the buildings and have no idea whatever that such a power as electricity exists. If the administrators of the Chicago World's Fair had achieved no other result, they have this undoubted claim to honor, namely, that they have taught the art of classification at international exhibitions. The position of affairs at Antwerp drives home the lesson, and surely it will never again be forgotten in future undertakings of the kind.

After the great efforts put forth by almost every nationality at Chicago last year, it was naturally to be expected that signs of exhaustion should be manifested at Antwerp in 1894. The two countries that show this symptom in most marked degree are Great Britain and the United States themselves. Owing largely to the operation of the McKinley tariff, British manufacturing industries were not adequately represented even at the Chicago World's Fair. The colonies, however, came to the rescue of the mother country—New South Wales and Victoria with splendid wool trophies; the former dependency with pyramids of gold, silver, tin, and copper ores, arches of coal and building stone, and a fine collection of hard woods; Canada with cereals, minerals, and timbers; the Cape of Good Hope with diamonds, wool, mohair, and ostrich-feathers; India and Ceylon with striking pavilions filled to repletion with manifold products; even little Jamaica, Trinidad, and British Guiana, each with a varied and interesting display. In this way the deficiencies of England proper were covered up, and the part played by the British empire was an impressive and a creditable one. At Antwerp, however, the colonies are practically unrepresented, with the result that the British section is one of the poorest within the buildings. The explanation lies in the fact that there is a sharply-divided line of opinion in England as to the practical utility of the unceasing round of international exhibitions. It is the doubt as to an adequate *quid pro quo* that causes the leading manufacturers to hold aloof, added in some cases to a feeling of uneasiness as to whether it is not giving trade secrets away to show wares and processes to all and sundry. Quite a different cause has conduced to the inadequacy of the United States representation. America has, alone among the nations, a building all to herself within the Antwerp Exposition grounds. Architecturally this edifice is a monstrosity; internally it is nothing short of being a ghastly failure, for there is not a single prominent line of manufacture or of production with which the name of the United States is associated all the world over that has exhibits to illustrate it. On two occasions when I entered the building the small number of visitors present were congregated round a woman of the "faker" class who was vociferously calling the praises of some new stone for sharpening knives, and disposing of the same at ten centimes per sample! To those who know anything about the resources of the United States, such a spectacle is merely ludicrous; but in the case of the ignorant—and the humble peasant folk who are flocking in great numbers to the Antwerp Exposition cannot be classed among the learned—inadequate representation becomes misrepresentation. No doubt the explanation of the fiasco lies in the fact that the manufacturers and producers of the United States made such a complete display at Chicago that they are content for a time to rest upon their laurels. If this, however, be the prevailing feeling in the country, it would have been better for the stars and stripes not to have been hoisted at Antwerp—not, at all events, over a special building which causes people to expect much and to experience a feeling of disappointment when they get so very little.

Africa, appropriately enough, holds a place of great prominence at the Antwerp Fair. Leopold III, king of the Belgians and titular monarch of the Congo Free State, has so identified himself with the opening up of the dark continent to civilization and to commerce, that no labor or expense has been spared to illustrate in his honor the work of African exploration and settlement. The village inhabited by some hundred and fifty natives from the Congo state is somewhat after the style of the Dahomey village in the Midway Plaisance, but it is on a larger scale, and, as the public is not allowed beyond the railing which encompasses the enclosure, the dark-skinned people are free to follow without interference their every-day avocations—grinding corn, weaving mats, working iron with the aid of a primitive bellows, and, in the case of the children, playing the simple games with which they are wont to amuse themselves in their far-away home. The picture is altogether a vivid and instructive one. But of infinitely greater importance is the vast technological exhibition which shows all the natural products of equatorial Africa, and also all manufactured articles which find a market among the natives. The latter section of the display is invaluable. It is a law of commerce that the manufacturer who would make his way in new countries must adapt himself to the prejudices or the caprices of his customers. Thus, in the Congo state an ordinary hammer or a spade would not find a ready sale; but let its shape be adapted slightly to the primitive wooden implements in common use, and the article at once secures eager purchasers. Here at Antwerp every conceivable article, from cotton blankets to colored handkerchiefs, hatchets to tin tacks, coils of wire to strings of beads, of shape and color and material most acceptable to the negro in his own country, are shown. Moreover, the exact method of most suitably packing the goods for human porterage, and so saving the shipper the cost of breaking bulk, is illustrated. The exhibits are very complete, and are splendidly arranged; and manufacturers from Germany, France, Belgium, and Great Britain are giving to this department of the Antwerp Fair very close attention. Africa is further brought prominently before visitors to the exhibition by the diamond-washing machinery of the De Beers Mining Company, familiar to every one who entered the Mining building at Chicago; and by a crushing, amalgamating, and concentrating plant shown in actual operation by the leading mines of the Transvaal republic. The latter exhibit is supplemented by an admirably arranged collection of ores which, from the novelty and the complete success of the method of displaying, deserves a special word of mention. A long table runs the length of one of the Transvaal pavilions. On this table a map of the main reef is drawn, every individual mine being marked out. On each claim samples of the ore are placed, with cards conveying such information as the depth whence taken, the milling average per ton, etc. A duplicate key map hangs on the wall above the table, and by its aid the mining expert or the speculator interested in various properties can walk along the table and inspect the ores he desires to handle.

Another art, besides that of classification which the men of Illinois taught the world, but by which the Belgians have failed to profit, is that of "booming the Fair." The columns upon columns of gratuitous press notices in every country on the face of the globe which the department of publicity, by untiring zeal and industry, secured for the Chicago Exposition, afford a striking contrast to the meager and infrequent references to the Antwerp undertaking. Perhaps not 5 per cent. of the populations of London, Paris, or Berlin have even now ever so much as heard of the Belgian international gathering. Then again, there are no fête-days, no national celebrations, no frequently recurring ceremonial functions, all of which helped to keep the enthusiasm at Chicago from flagging for a single twenty-four hours. Here the people of the city and the country seem to regard their own Fair with complete apathy. When one recalls the heroic work of entertaining and showing the marvels of their land performed last year by Chicagoans and by citizens of the United States generally, the national character of the Belgian and of the American becomes sharply differentiated. The general lethargy seems even to extend itself to the side shows. Many old faces from the Midway Plaisance,—Moorish and Bedouin, Turkish, and Cairene,—are present at Antwerp; but there is none of the rollicking fun of the never-to-be-forgotten international street at Chicago. Continental folk take their pleasures economically; and the francs of 1894 are less plentiful than the dollars of 1893. *Hinc illæ lacrymæ!*

Perhaps, however, the most striking contrast of all between Chicago and Antwerp is outside the exhibition gates. The Fair of last year was held in one of the newest cities in the world; that of the present year is located in one of the oldest and most historically interesting. At Chicago the great sights were intensely modern—the lofty office-buildings, the stock-yards, the grain-elevators, the whale-back lake-steamers. At Antwerp we are in the city of Rubens, the city endeared to Thackeray and Lever, the city which was the scene of the bloody Spanish fury, of many a fight, of many a prolonged siege. The very name of the architect of the beautiful cathedral of Notre Dame has been lost away back in the centuries. Hard by is the Plantin-Moretus museum, a living picture of a famous Flemish printing-house at the latter end of the sixteenth century, with all the paraphernalia of book-production three hundred years ago preserved intact. The visitor has only to repair to Old Antwerp, which occupies a corner of the exposition grounds, to complete the illusion and find himself transported back to medieval times. Here, after wandering through the ancient streets, one may pause in the spacious market-place and listen to old-time music sung by choristers in the old-time garb of doublets, hose, ruffs, and flat-fluted caps, to an accompaniment played by such old-time instruments as clarionets, hautboys, wooden flutes, and side drums—music of the quaintest, for although the words may be inspired by hilarious delight over the advent of spring, or by rapturous admiration of the charms of the goddess of Love, the tune is invariably of such funereal gloom that the listener imagines he is hearing some penitential hymn. After all, Old Antwerp—the real old Antwerp, such of it as has been spared by the gnawing tooth of time, as well as this reproduction of life in "ye olden days"—may be allowed to purge the Exposition of its sins of commission and of omission. The traveler does not come here to ascertain the latest applications of electricity or the most recent improvements in locomotive engines. We did all that at Chicago.

THE MODERN MECHANICAL DRAWING-ROOM.

By Professor C. W. MacCord.

JUST as the manuscript must precede the printed page, so the making of adequate explanatory drawings is an essential preliminary to the execution of any mechanical project; the compositor cannot set up the book without "copy," nor can the artisan proceed without the guidance of working plans. The provision of at least reasonable facilities for preparing them is therefore an important element in the design of a machine-shop, or other engineering establishment, making any pretensions to completeness,—a fact which seems so perfectly obvious now as to cause wonder that it ever should have been overlooked or neglected.

Yet it has been, of which proof convincing, to the writer's mind at any rate, is furnished by the surroundings amid which he acquired his first experience in professional practice. Imagine a room with its floor some steps below the level of the sidewalk; a small and dusty room, ill-lighted by an abortive skylight, and two windows upon one side; worse ventilated by one door opening into an equally dismal office, and another communicating directly with the foundry, whence drifted in a dull and heavy air, laden with smoke and evil odors; ornamented with graceful festoons of cobwebs, thrice magnified by accumulated grime and soot. The side windows, facing the west, opened upon a narrow driveway, on the opposite side of which were a dirty boiler-room and a noisy engine; beneath these windows was a sloping shelf whereon were placed the boards at which the draughtsmen stood or sat, while before their eyes, not ten feet off, the busy carts went up and down, laden with coal or iron, from morning until night. This unattractive picture, far from being overdrawn, really serves to give but a faint idea of the drawing-office of a large and famous establishment in New York city, at a period by no means so remote as yet to have passed into ancient history.

Now it is not to be denied that in this world of ours men have risen superior to circumstances, and accomplished much good work under very disadvantageous conditions. But it has been in spite of, and not by reason of, those conditions; and the same men, in our opinion, would have done more, or done it better, or both, had they been provided with greater facilities. From which it may be inferred, and rightly, that we conceive the designer of the room just described to have been guilty of nearly all imaginable sins both of omission and of commission; supposing that it was originally intended for the use to which it was actually put.

Clearly, the first requirement of the ideal drawing-office is light, and plenty of it. Moreover, the light should be as nearly uniform as possible, throughout the day. This is a very important consideration, to which we fear that due attention is not always given; and it obviously dictates that the windows in front of which the drawing-tables are placed should be neither on the east side nor the west: the weight of evidence, we believe, is in favor of a northern exposure. Should the room be in the upper story, there may be no objection to the use of a good skylight, of ground glass, for aiding in a diffused illumination: not, however, for a draughtsman to work by. Light coming from directly overhead, casts annoying shadows, and is most objectionable. The light should fall on the paper diagonally from the left; a good result will be attained by having the breadth of the window a little greater than the length of the drawing-board, and placing the latter, not centrally in front of the window, but somewhat to the right; some twenty inches from the wall, in order to give free access on occasion to the upper part of the board; and between the ends of adjacent boards a space of at least two feet should be allowed.

Having thus arranged a row of tables in front of the windows, a second row may be placed at a convenient distance back of them, the left-hand end of each being opposite the center of the one in front; and, supposing the windows to be of sufficient height, these also will be well lighted. For some of these a single long table may be substituted, should it be required, as in making plans of ships or bridges, or in laying out movements on a large scale.

Beyond this, however, it does not seem advisable to go, since experience shows that a third row if added would not, on very many days, receive an adequate amount of light. Thus, if a considerable number of men are to be employed, the scheme takes the form of a long and comparatively narrow room, with broad windows close together facing the north, and provided with two rows of tables placed *en échelon;* high, well ventilated, with a solid floor, and as free as may be from dust and noise.

It will greatly conduce to the neat and orderly appearance of the room if each draughtsman is provided with a locker, for the disposal of hats, overcoats, umbrellas, etc., as well as for the safe-keeping of T-squares and other instruments. These can be arranged in series along the side of the room opposite the windows, at the same time leaving ample space for chests of drawers or their equivalents for storing drawings, as well as for cases for spare drawing-boards.

At the eastern end of the room, next to the window, should be placed a roll-top desk, and at its right a bookcase for works of reference. At the opposite end may be placed a chest of drawers containing paper, tracing-cloth, and other materials, as well as such instruments—protractors, beam compasses, etc.—as may be provided by the office for general use. At the left of this, that is in the northwestern corner of the room, a reasonable space should be set off for a lavatory, and enclosed by a partition reaching half-way to the ceiling. Within this, in addition to conveniences for ablution, should be a small case for the sponges, water-glasses, paste, etc., to be used for damp-stretching paper on occasion.

The dimensions of the drawing-tables and boards will naturally be determined by the nature of the work to be done, and their construction upon individual preferences. The writer's experience leads to the belief that, for general work in a machine-shop, the permanent table should be large enough to take a sheet of double elephant size, which is $27'' \times 40''$; the table should be considerably larger, not only to leave space for instruments, but because it is often desirable to make use of centers and points outside the limits of the paper; $32'' \times 54''$ has proved a very convenient size. No material is better than well-seasoned, straight-grained white pine, free from knots and turpentine; the thickness for the above dimensions should be $1\frac{1}{8}''$; the board may advantageously be lightened and also weakened transversely by planing in the lower side a series of grooves from end to end, a half-inch deep and three-quarters wide, leaving ribs of the same width between them; it should then be stiffened transversely by two hard-wood battens snugly fitted into dove-tailed grooves, but not fastened, —thus leaving the board free to expand and contract as it will. If two or more pieces are required to make up the breadth, they should be simply matched and glued, not tongued and grooved; and, finally, no paint, oil, or varnish of any description must on any account be applied to either back or front. Such a board, supported by a substantial wooden frame of the "saw-buck" pattern, or by an iron one of lighter design, but in either case firmly and rigidly, forms a most satisfactory table; it should be provided with a drawer large enough to contain all the "case instruments" and minor appliances.

In addition to these permanent tables, there should be a sufficient number of portable drawing-boards; two very convenient sizes are $24'' \times 40''$, and $20'' \times 30''$; these are made in the same manner as the others, except that, instead of grooving the backs, it is enough to make a series of slits three-quarters of an inch apart, by running the boards lengthwise over a circular saw. These when not in use can be snugly stowed away in cases, being supported at each end by cleats, like the shelves in a bookcase. The front of the case must of course be closed to exclude dust,—and preferably by a vertically-sliding flexible arrangement like the cover of a roll-top desk. A similar flexible apron, it may be suggested, might be advantageously adapted to a chest of drawers; for its use would permit the drawers to be made without fronts, which would greatly facilitate the handling of the contents, particularly if the latter consist of sheets nearly as large as the drawers. And this ought at least to be the case in regard to the office supply of drawing-paper. It is simply not possible for a draughtsman to work either well or rapidly unless his paper lies flat on the board, which a piece cut from a roll will not do, unless the "set" be taken out of it by damp-stretching; paper in the roll may be a trifle cheaper in first cost, but the loss of time will make it much dearer in the end; the work put upon it is of far greater value than the material itself, which should be procured in sheets, and *kept flat* in drawers of suitable size, so as to be ready for use on the instant.

Thus far nothing has been said of facilities for making blue-prints, which may be regarded as essential to the completeness of a drawing-office. But as an adjunct only, the production of drawings is quite distinct from their reproduction by any photographic process, and the light best adapted to the former is probably about the worst for the latter. It would seem that a printing-room constructed like a small observatory, standing by itself upon a flat roof, would be most advantageously situated; should this not be feasible, the choice in this latitude would fall upon a room whose windows face the south. Of these there should be two, and wide ones; a substantial platform with its top flush with the window-casing, outside of one of them, will afford facilities for the exposure of the smaller printing-frames. Through the other may project to a suitable distance a pair of iron ways, extending well within the room; upon these runs a truck carrying a turntable, to which are fixed two upright brackets, supporting the printing-frame by trunnions secured in the middle of each end; in this way the largest and heaviest frame may be manipulated with great ease. Within the printing-room should be constructed a small dark-room for preparing the paper—which has been found to be cheaper and more convenient than procuring it ready-made.

Blue-prints to be sent into the shop should be made upon comparatively thin paper; those of small size may be mounted by pasting them down either on smooth thin deal-boards or on heavy binder's board; larger ones might well be mounted on cloth, like maps, and stretched on light wooden frames: in either case they should receive when thoroughly dry a coat of clear shellac varnish. And the printing-room must be provided with the necessary conveniences for performing all these operations, which evidently could not be well done in the main drawing-room, for many reasons, then, these rooms should be separated. In the present state of the photo-printing art, it seems that the process above alluded to is the one most available for the multiplication of working drawings. The reproductions are sharp, the operation is neat and rapid ; but the effect of white lines and figures on a blue ground is very trying to the eyes, and it is sincerely to be hoped that in the near future this arrangement may be reversed. Two processes have come to the writer's notice, by which dark lines are produced on a nearly white ground ; one, however, was by no means as convenient, and neither brought out the lines as sharply as blue-printing.

In the writer's mind there is no question that the most satisfactory course is to have all the drawings of every machine finished in ink upon paper of good quality ; and these originals should not be permitted to leave the drawing-office. In working out details there is frequent occasion to compare one drawing with another,—in planning one part it is often necessary to refer to the drawings of several other parts already completed, in order to make sure that all the dimensions agree and that the harmony of design is preserved ; again, since no human work is infallible, there is always a possibility that some discrepancy may be discovered, and a complete set of plans should be always at hand, so that any error may be traced to its source and the requisite alterations made. It is not, of course, absolutely necessary to ink in the originals, since tracings can be made from lines firmly pencilled ; but the course suggested is on many accounts advisable. Whether it is adopted or not, however, it may be remarked in passing that it is well for every draughtsman to acquire the habit of pencilling in such a way that the whole or any part of a drawing can if necessary be traced without waiting for the inking process, which he can do with but moderate effort.

The custom obtains to a limited extent of having all drawings sent into the shop, or at least all those relating to any one machine, made upon sheets of uniform size. There is no doubt that this system has some practical advantages, especially in regard to the storing away of the plans, and the facility of finding any particular sheet when wanted. But it would seem that these advantages must ordinarily involve the expenditure of extra time and labor. Because in planning, it is not always possible to determine beforehand precisely how much room will be required ; as the work progresses and the scheme is developed, some new idea may suggest itself, the perfect illustration of which requires more views, or takes up more space, than had at first been contemplated. Should the sheet thus prove to exceed the specified size, it would be necessary to make a new drawing upon a smaller scale ;

and, in order to secure a pleasing uniformity of appearance, a reverse proceeding would be required should it turn out much too small.

Another, and a more common system, is to select a scale (which can usually be done without difficulty), such that the drawing of the particular piece in hand shall not exceed a certain maximum size, say that of a double elephant sheet, and, if it prove smaller, to cut down the paper so as to leave a reasonable margin. This system is more economical in the drawing-office and equally effective in the shop: and when it is adopted it will very often happen that the drawings of a given machine can be advantageously cut, if not to one uniform size, yet so that two or three different sizes will be sufficient for the whole set.

It is necessary to keep a catalogue, or book of record, in which is to be entered, as soon as completed, every original drawing which is to be preserved, with an indication of the place in which it is to be kept. Various systems of letters, numbers, and symbols have been devised with a view to ready reference, as well as to checking the delivery and the returning of duplicates. It is not within the scope of this paper to discuss the merits of these, much less to recommend the general adoption of any particular one; indeed, it is easy to see that a code which would answer admirably in one place, might prove to be wholly unsuitable in another. One thing, however, may be advised as of universal application,—which is, that every machine or engine should have a distinctive shop-name or number, and that, upon every drawing pertaining to it, this name or number should be prominently inscribed, followed, in less conspicuous characters, by a specific statement of the parts represented, and this in addition to any scheme of lettering or numbering.

Now, the object of working drawings is to show the workman what to make and how to make it, and this they must do both distinctly and unmistakably: and experience proves that drawings may be technically correct, and yet fail to accomplish this object,—they may lack the indescribable something upon which the *explanatory* quality depends. The most efficient and valuable man in the drawing-office is the one who, with the least expenditure of time and labor, can produce such work as will enable the construction to be carried forward with certainty and dispatch. For this purpose it is not sufficient that the drawings should be correct as studies of projection; they must be so selected and arranged as to be clearly and easily read. It is not possible to lay down any rule as to how many views of any piece shall be made, or what views they should be; this must often depend upon the nature of the case, and these points must be decided by good judgment and common sense, aided by experience. But the novice must be cautioned against the idea that an end view, a side view and a top view are always needed and always sufficient. Just such and so many views must be made as will make the meaning clear beyond doubt ; it must be kept in mind that a little time spent in the drawing-office is often saved many times over in the shop. Before sending out a sheet, let it be made certain that the drawings and annotations are such that, if followed, the workman can make what is wanted and cannot possibly make anything else : then, and then only, is the work complete.

Sometimes, especially if machines are to be manufactured by the quantity, with interchangeable parts, it is advisable to make a separate drawing of every individual piece. But this is not always necessary ; for there must be drawings to show how these pieces are assembled, and the latter will in many cases answer both purposes. Take, for example, the connecting-rod of a steam-engine ; a drawing which represents it as put together ready for use exhibits perfectly the construction of its component parts, and is even more explanatory than if the straps and brasses, gibs and keys, had been separated and scattered over the paper in isolated drawings. And the ability to *condense*—to reduce the number of drawings without sacrificing perspicuity—is a qualification of great value, ranking next, indeed, to the all-important one of determining the best views, and the best arrangement of them, in any given case. Both these powers are to a certain extent intuitive, but, like all others, may be increased by cultivation ; and the subordinate, desirous of advancement, even if he have nothing else to do at first but to make tracings, will be able to learn much in these directions if he will but study the plans while engaged in that necessary drudgery.

Curiously enough, given a taste for mechanical pursuits, and some familiarity with mechanical details, these powers may be developed to a very high degree without any corresponding gain in ability to design. We have known more than one who, while competent to make from the rudest dimensioned sketches an accurate and perfect set of working drawings, could neither devise a new contrivance for any given purpose, nor determine the proportions of an old one. Notwithstanding these limitations, such an one may be found a most valuable assistant, particularly if his mathematical acquirements are such as to be serviceable in making computations of weights, centers of gravity, and the like, which are often necessary.

The *designing* of any engine or machine is a comprehensive term, including the devising of the mechanical movements, the determination of the general arrangement and magnitude, and the elaboration of the specific arrangement, as well as of the precise dimensions of the details. In regard to these there is great diversity of individual capacity ; thus one may be especially skilled in the geometry of motion and the construction of diagrams, another may be better able to select the one which should be adopted, and display greater fertility of resource and a sounder judgment in the neat and compact disposal of details, while neither might be as competent as another to determine the leading dimensions or proportions. The master of course is he who is equally at home in all, but they seem somehow to depend upon different qualities of mind—just as an excellent colonel might prove a bad general—and these qualities are rarely found combined and symmetrically developed in one and the same person.

The working out of details involves consideration, not only of the strength of materials, but of ease of access and repair, as well as of facility and cost of construction ; some knowledge of the operations in the shop, then, is an essential requisite. It is not necessary, however, that the draughtsman engaged upon such work should have "served his time" and become an expert mechanic. But in order to be thoroughly efficient, he should have had the opportunity to acquire both by practice and observation some familiarity with the manipulations in the pattern-shop, the foundry, and the fitting-shop. If he has had previously the advantages of a theoretical training in a technological school, so much the better, but whether he has or not, this practical schooling will subsequently benefit him in two ways : it will enable him to plan in such a way as to avoid needless expense and difficulty in construction, and, what is important, although sometimes overlooked, it will give him a positive apprehension of proportions. Having before him at once both the drawing and the thing drawn, he is compelled to grasp the relation between the two, and thus can thereafter judge more accurately of how his designs will look when executed.

On the principle that the greater includes the less, the head of the office should logically possess in a superior degree all the qualities and accomplishments of his assistants. This may be too much to expect—many a foreman has under him men more expert in special lines—but he should command their respect not only for technical skill, but for his education, personal character, and experience, particularly experience in the kind of work for which the shop is equipped. A "chief draughtsman," as that term is generally used, is in reality a constructing engineer ; and mechanical engineering is so subdivided that superlative excellence in all its branches is beyond human attainment. So, for instance, the chief in a locomotive-shop would not, ordinarily, be competent to fill a similar place in a shop devoted to heavy marine work, and *vice versa :* while neither might do well at the head of an establishment for building machine-tools, or one for doing electrical work. Naturally, the best work in a special line will be accomplished in a shop devoted exclusively to it; but a more varied experience can be gained in shops where the work is of a miscellaneous nature, giving those who acquire it an advantage like that of an "all-around" mechanic over him whose skill is confined to the use of a single tool, as a planer or a lathe. The style of an author is influenced without his knowledge by the books he has read, and a wide range of reading is of benefit to him, no matter how original his ideas. And so the store of precedents thus laid up would be of advantage to the chief in a shop where new designs of new machines are in frequent demand; because in planning the mind is often unconsciously guided by analogy and by mental deductions from previous practice. But whatever his own qualifications may be, he must remember that the most successful generals have always been those who made the most judicious selection of their lieutenants; by studying the capacity and acquirements of his subordinates, dividing the work among them so that each shall have the task for which he is best fitted, and that in such a way as to let him understand that his value is appreciated, he will not only lighten his own labor, but, while securing greater efficiency, will more firmly establish himself in the esteem of his assistants and of his employers.

THE LAW GOVERNING STRIKES AND STRIKERS.

By Senator Cushman K. Davis and Judge Peter S. Grosscup.

NO recent period in the history of the United States has been more productive of brilliant declarations of the principles of free government, than that of the great railroad strike through which we have lately passed. Betwixt the Socialists and the Anarchists, the Bellamys and the Georges, the Populists and the whole brood of fiat-money fools, the atmosphere of civilized society is so charged with economic fallacies, and the public prints are so burdened with abuse of "trusts" and "corporations" and "capitalists"—practically every form of wealth, indeed—that it is small wonder the ignorant, the vicious, and the criminal elements of society regard themselves as the innocent victims of "rich men"; that labor leaders counsel and carry into effect measures which outrage the most obvious principles of liberty and equality; and finally, that every great strike is now simply the signal for riot, murder, arson, and anarchy.

We have, of course, had the usual flood of fine writing upon the subject, with no lack of effort at oratorical effects by the politicians and demagogues. But the feature of this period of labor disturbance, which broadly distinguishes it from previous ones, lies in the perfectly clear expositions of the law governing strikes which has been called forth, alike from the legislative, executive, and judicial branches of our government. Nothing in all judicial literature, for example, is finer, clearer, or stronger than Judge Grosscup's charge to the grand jury which indicted Debs and the other officials of the American Railway Union; nothing in the annals of free government is more inspiring than the impromptu, spirited, and patriotic deliverance of Senator Cushman K. Davis, of Minnesota, in reply to the seditious demand of the Populist Senator from Kansas (Peffer) that the government be given over to anarchy; and not since Lincoln's time have we had a grander example of statesmanship, or more signal evidence of the fitness for rule, than was shown in President Cleveland's masterful grasp of the opportunity to prove, once for all, that the Nation's army is here to enforce the Nation's law of liberty and protection to life and property.

Amid the mass of sensational matter recorded by the newspapers during the strike, the significance of these legal expositions was doubtless overlooked by many,—perhaps by some who may yet be called upon to face scenes similar to those enacted at Chicago. It is important, therefore, to distinguish the fact that these declarations were neither partisan manifestos issued to catch votes, nor moves to checkmate a rival in the game of politics. On the contrary, they were official declarations of the law under which we live. Back of every sentence were bayonets, and back of the bayonets was a Nation of aroused and enlightened freemen, bent upon the preservation of order and the defense of the inherent natural right to enjoy "life and liberty, *with the means of acquiring and possessing property*"—as was so pointedly stated in the first charter of American liberty, the Virginia Bill of Rights.

Now that the turmoil and excitement are past, and there is time for reflection, it seems both proper and important that people of intelligence generally, and the readers of this Magazine in particular—so many of whom are large employers of labor—should clearly comprehend the legal principles which governed the armed forces of law and order at Chicago and elsewhere, and which must be operative in future labor disturbances. We therefore reproduce here the essential portions of the official declarations which are deemed of most importance.—THE EDITOR.

IN the United States Senate on July 10, 1894, Mr. Peffer, the Populist Senator from Kansas, delivered his astounding speech in advocacy of his resolution presented the previous day, which demanded the purchase by the government of all railroads and coal-beds; the regulation of wages and hours of labor by law; the issue of all money by the national government exclusively; and finally, the collection of all public revenues by means of Henry George's single tax. The entire speech may be fairly described as an angry protest against all existing institutions and a defense of the riotous railway strikers in Chicago and elsewhere; and the climax was reached when he said:

"I wrote to a friend the other day that I was ready for the abolition of the Senate and would be willing to vote for it; and I would go still further and vote for the abolition of the House of Representatives; and I would favor that the personnel of the Government should be confined to a few men, not to exceed one from each State, and let them select a presiding officer from their own number."

It was in reply to this socialistic harangue that Senator Davis, of Minnesota, delivered the ringing speech which electrified the country and roused both the Senate and the whole people to a proper appreciation of the outrages that were being enacted at Chicago and elsewhere. The speech is far too long for reproduction here, but we give enough of it to clearly indicate the character of the whole. Said he:

"At a time when in the second city of the United States, and the fourth or fifth city in the civilized world, order is suspended, law is powerless, violence is supreme, life is in danger, and property is in the very arms of destruction, I am appalled to hear the trumpet of sedition blown in this Chamber to marshal the hosts of misrule to further devastation.

"This question does not now concern the issue between the Pullman Company and its employés. It has got beyond that. It does not concern the sympathetic strike of the American Railway Union. It has got beyond that. It does not concern any strike which may hereafter be ordered. It has gone far beyond that. A simple strike as to a local organization, not directly connected with the transportation instrumentalities of this country, grew into another strike of far more comprehensive proportions. That grew into a boycott. That boycott took the liberty of the American people by the throat, and then grew into a riot, and from thence into an insurrection which confronts this Government to-day with all the dormant and latent powers of revolution, and speaks here in the voice of its advocate, threatening and advising the dismemberment of the Government by the abolition of its executive and legislative departments.

"The Senator from Kansas speaks of the rights of labor, and in the abstract I am with him. No one denies that there are before the American people to be settled, in a lawful and constitutional manner through their legislative functions, vast questions of adjustment between the rights of labor and capital. No one denies that. It is the great problem of civilization all over the world. Man and machinery have been worked so into each other, through complex organizations of both, that sometimes it cannot be discerned where the man ends and the machinery begins. But in these times of present exigency and danger to government itself those are not the questions. The Senator from Kansas has not a single word of reproach for the blood that has been shed in Chicago in the last ten days, for the millions of property which has been destroyed. The red light of arson against the sky in that city has caused him no pang and elicited from him no word of disapprobation.

"People prate about liberty, and define that liberty as the liberty of *the particular class* they are speaking for. *The only liberty worth having in this country is the equal liberty of all men alike.* Liberty in its philosophical and common-sense definition consists in *that right of each individual to exercise the greatest freedom of action up to, and not beyond, that point when it impinges upon the like exercise of freedom of action of every other man.* Beyond that it is the destruction of the liberty of the weak by the strongest, a subversion of the very theory of a republic, and a return to primeval anarchy on the one hand, or, as an alternative, to despotism on the other.

"The Senator from South Dakota (Mr. Kyle) introduced into the Senate the other day a resolution, the substance of which is that no process, civil or criminal, shall issue from any court of the United

States in regard to acts affecting interstate commerce by the obstruction of trains, unless such acts involve the delay of the mails, and that the detaching of Pullman cars from any train shall not constitute an offense. At the time that resolution was introduced interstate commerce was arrested at Hammond, Ind., it was in collapse at Chicago, and freight, common passenger cars, and Pullman cars were being destroyed in that city. The meaning of that resolution is that, while these acts were flagrant and being committed, the United States was to be called upon to make itself an accessory to the crime while it was in the act of perpetration.

"Now consider the importance of the relations of this Government to interstate commerce. A clause in the Constitution, contrived by the wise foresight of our forefathers, has become efficacious and widespread in its operations a hundred years after it was framed. The railroads of this country, 176,000 miles in length, belting this land and laid over it like a network of iron, an armor of defense, are the daily convenience and the indispensable necessity of every man, woman, and child in the United States; and this movement is aimed at this great instrumentality, this great necessity, this indispensable convenience of our civilization, necessary to support life, to move troops, to move supplies, to carry on the Government itself. And by what acts? Tearing up the tracks, derailing locomotives, overturning cars across the tracks, burning them, robbing trains of provisions, disarranging switches,—all with the result of the loss of human life; and yet the resolution of the Senator from South Dakota proposes to take away from the United States courts the power to follow, repress, or punish these flagrant offenses against everything which goes to make up civilization and security.

"The sea, the great lakes, the rivers, everything within the admiralty jurisdiction of the United States, were once the main instrumentalities of commerce, and there is a stringent code of laws applicable to them and to the ship, as security for persons and passengers and the means of conveyance. I say here, without fear of successful or even attempted contradiction, that if any one of the acts which have been perpetrated in Chicago in the last ten days against persons and property of this great means and necessity of land communication, had been perpetrated upon the waters within the admiralty and maritime jurisdiction of the United States, those acts would have been piracy and punishable with death under the statutes of the United States.

"The authority of the United States cannot be denied. Within the limitations of the Constitution it is supreme. The duty of the President of the United States is to see that the laws are faithfully executed; the duty of the courts is to declare those laws and their consequences, and to execute them through their process. Is the interstate commerce of this country to be held in suspense and paralyzed, property destroyed, food cut off, conveniences taken away, necessity thwarted, until some remote disagreement as to wages between a private corporation and its employés can be adjusted? Is there any such reserved right as that to any of the citizens of the United States? Or is it the mere usurpation of a mob, commencing in riot and tending towards anarchy?

"Speaking of the people of the United States—a large, mouth-filling phrase that we have heard so often here—let us consider a moment that there are 5,000,000 farmers in the United States. Five million farmers and their families, constituting 45 per cent. of the population, are engaged in agricultural pursuits. I suppose that if anybody is entitled to be distinctively called 'the people,' the bone and sinew of this country, it is the farming population. *They supply the great cities. They represent the land; without them the country would be nothing.* They have been its invulnerable and loyal arm of defense in all times of peril. How are they affected by this strike of that segment of the people in Chicago? Have the farmers of this country called out to have commerce stopped until the question of wages can be settled between a few employés and a company constructing cars? Has any Illinois, or Minnesota, or Wisconsin, or Iowa farmer cried aloud for this remedy, and been ready to pledge his life, his fortune, and his sacred honor until the desired end can be brought about? Not one. How has it affected them? How does it affect the constituents of the Senator from South Dakota, or the constituents of the Senator from Kansas? They cannot market their wheat if this thing continues; they cannot market their wheat to-day. The early product of the farms of Illinois, the fruit, the early vegetables, have been rotting throughout the fields. The early fruitage of California has become a crop perfectly valueless under existing conditions. The beef of the country cannot be marketed in New York or Washington. It is rotting in Chicago,—and prices rise to the people. Mothers go from place to place in the city of Chicago seeking for milk for their children, and can scarcely find it. I say that no interest in this country is stricken such a deadly blow by this cruel, remorseless, unreasonable, merciless, and finally treasonable attack upon the liberty of the American people as the farming community of the United States; and they will find it out some day by the stern logic of events teaching them the lessons which I have endeavored to impart.

"The time will come in the new order of events when these matters will be satisfactorily arranged, for this Republic has always been adequate to every emergency, and these disturbing questions between capital and labor—they exist with strong equities in them, I admit—will be settled. I think that time is now upon us. But they will not be settled as the result of any such proceedings as those against which I speak to-day. Something more than capital, for which I care nothing; something more than the wages of the laboring man, for whom I care much; something more than a railway corporation, for whom I care nothing, is at stake here. National existence is at stake."

After a patriotic and stirring address of this character it is scarcely necessary to add that the following resolution was passed by an overwhelming majority—thus finally and forever putting an end to the absurd idea that the national government is without supreme authority to regulate commerce between the States over the Nation's great highways, the railroads:

> *Resolved*, That the Senate endorses the prompt and rigorous measures adopted by the President of the United States and the members of his Administration to repulse and repress by military force the interference of lawless men with the due process of the laws of the United States and with the transportation of the mails of the United States and with commerce among the States.

On the same day, and almost at the same hour that this stirring scene was enacted at Washington, another equally memorable event occurred at Chicago. A grand jury had been summoned before Judge Peter S. Grosscup, of the United States District Court, to pass upon the criminal responsibility of the leaders of the strike. It was an impressive occasion, a climax in the history of labor disturbances in the United States, and it was the judge's charge far more than the jury's subsequent finding that made it so. Said he:

"GENTLEMEN OF THE GRAND JURY: You have been summoned here to inquire whether any of the laws of the United States within this judicial district have been violated. You have come into an atmosphere and amid occurrences that may well cause reasonable men to question whether the Government and laws of the United States are yet supreme. Thanks to resolute manhood and to that enlightened intelligence which perceived the necessity of a vindication of law before any other adjustments are possible, the Government of the United States is still supreme.

"You doubtless feel, as I do, that the opportunities of life under present conditions are not entirely equal, and that changes are needed to forestall some of the dangerous tendencies of current industrial life. But neither the torch of the incendiary, nor the weapon of the insurrectionist, nor the inflamed tongue of him who incites to fire and sword, is the instrument to bring about reforms.

"To the mind of the American people, to the calm, dispassionate, sympathetic judgment of a race that is not afraid to face deep changes and responsibilities, there has as yet been no appeal. Men who appear as the champions of great changes must first submit them to discussion—discussion that reaches not simply the parties interested, but the wider circles of society, and must be patient as well as persevering until the public intelligence has been reached and a public judgment made up. An appeal to force before that hour is a crime not only against the government of existing laws, but against the cause itself, for what man of any intelligence supposes that any settlement will abide which is induced under the light of the torch or the shadow of an overpowering threat?

"With the questions behind present occurrences, therefore, we have, as ministers of the law and citizens of the republic, nothing to do. The law as it is must first be vindicated before we turn aside to inquire how law or practice as it ought to be can be effectually brought about. Government by law is imperilled, and that issue is paramount.

"Now, the laws of the United States forbid, under penalty, any person from obstructing or retarding the passage of the mail, and make it the duty of the officers to arrest such offenders and bring them before the Court. If, therefore, it shall appear to you that any person or persons have wilfully obstructed or retarded the mails, and that their attempted arrest for such offense has been opposed by such a number of persons as would constitute a general uprising in that particular locality, and as threatens for the time being the civil and political authority, then the fact of an insurrection within the meaning of the law has been established, and he who by speech, writing, or other inducement assists in setting it on foot or carrying it along, or gives it aid or comfort, is guilty of a violation of law.

"The Constitution places the regulation of commerce between the several States and between the States and foreign nations within the keeping of the United States Government. Anything which is designed to be transported for commercial purposes from one State to another, and is actually in transit, and any passenger who is actually engaged in any such interstate commercial transaction, and any car or carriage actually transporting, or engaged in transporting, such passenger or thing, are the agencies and subject matter of interstate commerce, and any conspiracy in restraint of such trade or commerce is an offense against the United States. If it shall appear to you that any two or more persons corruptly or wrongfully agreed with each other that the trains carrying the mails and interstate commerce should be forcibly arrested, obstructed, and restrained, such would clearly constitute a conspiracy.

"If it shall appear to you that two or more persons corruptly or wrongfully agreed with each other that the employés of the several railroads carrying the mails and interstate commerce should quit, and that successors should, by threats, intimidation, or violence, be prevented from taking their places, such would constitute a conspiracy.

"I recognize however the right of labor to organize. Each man in America is a freeman, and so long as he does not interfere with the rights of others he has the right to do with that which is his what he pleases. In the highest sense a man's arm is his own, and, aside from contract relations, no one but himself can direct when it shall be raised to work or shall be dropped to rest.

"The individual option to work or to quit is the imperishable right of a freeman. But the raising or dropping of the arm is the result of a will that resides in the brain, and, much as we may desire that such wills should remain entirely independent, there is no mandate of law which prevents their association with others and response to a higher will. The individual may feel himself, alone, unequal to cope with the conditions that confront him, or unable to comprehend the myriad of considerations that ought to control his conduct. He is entitled to the highest wage that the strategy of work or cessation from work may bring, and the limitations upon his intelligence and opportunities such that he does not choose to stand upon his own perception of strategic or other conditions.

"His right to choose a leader—one who observes, thinks, and wills for him; a brain skilled to observe his interest—is no greater pretension than that which is recognized in every other department of industry. So far, and within reasonable limits, associations of this character are not only not unlawful, but are, in my judgment, beneficial, when they do not restrain individual liberty and are under enlightened and conscientious leadership.

"But they are subject to the same laws as other associations. The leaders to whom are given the vast power of judging and acting for the members are simply, in that respect, their trustees; their conduct must be judged like that of other trustees by the extent of their lawful authority and the good faith with which they have executed it. No man in his individual right can lawfully demand and insist upon conduct by others which will lead to an injury to a third person's lawful rights. The railroads carrying the mails and interstate commerce have a right to the service of each of its employés until each lawfully chooses to quit, and any concerted action upon the part of others to demand or insist under any effective penalty or threat upon their quitting to the injury of the mail service or the prompt transportation of interstate commerce, is a conspiracy, unless such demand or insistence is pursuant of a lawful authority conferred upon them by the men themselves, and is made in good faith in the execution of such authority. The demand and insistence, under effective penalty or threat and injury to the transportation of the mails or interstate commerce being proven, the burden falls upon those making the demand or insistence to show lawful authority and good faith in its execution.

"Let me illustrate: Twelve carpenters are engaged in building a house. Aside from contract regulations, they each can quit at pleasure. A thirteenth and fourteenth man, strangers to them, by concerted threats of holding them up to public odium or private malice, induce them to quit and leave the house unfinished. The latter in no sense represent the former or their wishes, but are simply interlopers for mischief, and are guilty of conspiracy against the employer of the carpenters.

"But if upon a trial for such results they prove that instead of being strangers they are the trustees, agents, or leaders of the twelve, with full power to determine for them whether their wage is such that they ought to continue or quit, and that they have in good faith determined that question, they are not then, so far as the law goes, conspirators.

"But if it should further appear that the supposed authority was used, not in the interest of the twelve, but to further a personal ambition or malice of the two, it would no longer justify their conduct. Doing a thing under cloak of authority is not doing it with authority.

The injury of the two to the employer in such an instance would only be aggravated by their treachery to the associated twelve, and both employer and employés should with equal insistence ask for the visitation of the law.

"If it appears to you, therefore, applying the illustration to the occurrences that will be brought to your attention, that any two or more persons by concert insisted or demanded, under effective penalties and threats, upon men quitting their employment, to the obstruction of the mails or interstate commerce, you may inquire whether they did these acts as strangers to these men, or whether they did them under the guise of trustees or leaders of an association to which these men belonged.

"And if the latter appears, you may inquire whether their acts and conduct in that respect were in faithful and conscientious execution of their supposed authority or were simply a use of that authority as a guise to advance personal ambition or satisfy private malice.

"There is honest leadership among these, our laboring fellow citizens, and there is doubtless dishonest leadership. You should not brand any act of leadership as done dishonestly or in bad faith, unless it clearly so appears. But if it does so appear, if any person is shown to have betrayed the trust of these toiling men, and their acts fall within the definition of crime as I have given it to you, it is alike the interest, the pleasure, and the duty of every citizen to bring them to swift and heavy punishment.

"I wish again, in conclusion, to impress upon you the fact that the present emergency is to vindicate law. If no one has violated the law, under the rules I have laid down, it needs no vindication, but if there has been such violation there should be quick, prompt, and adequate indictment.

"I confess that the problems which are made the occasion or pretext for the present disturbances have not received the consideration they deserve. It is our duty as citizens to take them up, and, by candid and courageous discussion, ascertain what wrongs exist and what remedies can be applied. But neither the existence of such problems nor the neglect of the public hitherto to adequately consider them justifies the violation of law or the bringing on of general lawlessness.

"Let us first restore peace and punish the offenders of the law, and then the atmosphere will be clear to think over the claims of those who have real grievances. First vindicate the law. Until that is done no other questions are in order."

There is no hidden meaning here. It tells in language so simple that he who runs may read the dictum that from this date forward order must and will be preserved. This exposition of the law may indeed be regarded, not alone as the most explicit, but assuredly the most influential that our labor disturbances have yet called forth. Its influence has already been reflected in the decisions of other courts in various parts of the country, and notably by Judge Hopper of the County

Court of Passaic county, New Jersey, who on the 8th ultimo, in sentencing the men who resorted to Anarchistic methods to influence the strike of the silk-weavers at Paterson, said in part :

" Most, if not all, of the men engaged in these acts of violence were of foreign birth, and were either blindly ignorant or wilfully regardless of the rights and privileges of free American citizens. Every man in this free country has the constitutional right to work for any one who agrees to employ him, and to quit work whenever he chooses, and no one has the right to force him to do either. An employer has the right to engage men to work for him upon such terms and at such wages as they shall mutually agree and to discharge his employés or close his works whenever he may choose. Whoever undertakes to interfere with them by forcible means is guilty of a crime and should be summarily punished. Workingmen have the right to organize and form associations and by peaceable means endeavor to secure an increase of wages and otherwise improve their condition. But when they resort to force and destroy property or attack their fellow workmen to accomplish their ends they violate the fundamental principles of our free government and are not worthy to claim to be American citizens.

" The open or secret principles of anarchy or socialism, so called, upon which these violators of law claim to have acted never can and never should be allowed to gain a foothold in this free country. It is strange and unaccountable that workingmen will willingly submit to the tyranny exercised over them by Master Workmen, so called, often self-appointed leaders, who by their arbitrary orders compel men to quit work and with their families either suffer and starve or rely upon charity for subsistence. This has notably been the case in the late extraordinary scenes among laboring men in the west.

" By the mere *ipse dixit* of a self-constituted leader thousands of workmen have been compelled to strike out of mere sympathy with others, with whom they have no connection or interest whatever, and millions of dollars' worth of property have been destroyed. The timely action of the President of the United States has shown the utter futility and absurdity of such measures, and that the laws of the country will be enforced and the men guilty of such unlawful acts be brought to deserved punishment."

ELECTRICITY

Conducted by Franklin L. Pope.

REFERENCE was made in this Department about a year ago to the Wolff chemical process of treating sewage, by means of a liquid termed by its inventor "electrozone," obtained by the electrolytic treatment of sea-water, and to an electrochemical plant which had been installed near Brewster's, N. Y., for the purpose of purifying the water flowing into one of the streams of the Croton basin from which the city of New York derives its water-supply. This purifying plant having now been kept in continuous operation for over a year, it is possible to form some idea of the practical merits of the process. One very striking fact is that the mortality in New York city from diarrhœal diseases and from typhoid fever has fallen off perceptibly during the past year. For ten years prior to 1893 the average death-rates due to these two forms of disease were respectively 2.18 and 0.26, while for the year 1893, notwithstanding the increase of population, the rates have been only 1.75 and 0.20. A test, made by Dr. E. A. Martin, chemist of the health department of New York city, proved that a sample of sewage containing 10,000,000 bacteria per cubic centimeter was rendered perfectly sterile by this process in 1 hour and 30 minutes. The electrozone is produced by converting the chlorids of the sea-water into hypochlorites and hypobromites by passing through it, between zinc and platinum electrodes, an electric current of 4 or 5 volts and several hundred amperes.

IN a recent number of the *Electrical Engineer* Mr. T. C. Martin gives an interesting and amply-illustrated account of the remarkable results which have attended the application of the Wolff process to the vast body of refuse from the city garbage-dumps which has been accumulated upon the shores of Riker's island, in the East river, not far from Port Morris. By midsummer of the present year, the aggregate amount of this refuse was estimated to be not less than 1,000,000 cubic yards. It covered an area of some 30 acres to a depth of 10 or 12 feet, and emitted the most nauseous stenches. An electrozone plant is installed upon a barge, capable of delivering about 4000 gallons per hour of the disinfecting liquid. The sea-water is first pumped into vats on board the barge, and subjected to the electrolytic process, and is then forced through several lines of hose, by means of which it is sprayed over the whole surface of the festering mass. The deodorizing effect, according to the personal investigations of Mr. Martin, has been little less than astonishing, and in this opinion he is supported by physicians and chemists of high standing. A permamanent plant is now in process of erection by which it is intended to treat the garbage as fast as it arrives on the island.

ELECTROZONE, it seems, is finding many other uses besides the one above alluded to. In all cases of suppuration and skin-diseases arising from micro-organisms, carbuncles, abscesses, and the like, its germ-destroying properties render it a most valuable means of treatment. It is also stated to have been applied with great success to the treatment of wood-pulp in the manufacture of paper. Thus, in a new field, electricity is once more proving itself to be one of the most universally useful, not to say indispensable, factors of modern civilization.

A RECENT journey through the interior of New England shows a condition of great activity among the local telephone-exchanges. A great number of these systems are being entirely rebuilt, with new and heavy poles, new wire, and improved construction generally, while the number of trunk-lines between the principal business points is being largely increased. All this points to immediately increased facility of communication, and ultimately to lessened cost. Nothing is more probable than that the time will come when every house will have its telephone, as much as a matter of course as it now has its clock and its sewing-machine. The problem of lessening the cost of telephone-service so as to bring it within the reach of every person of moderate means, while apparently a very simple one, to the uninitiated, is in reality one of the most complex which has ever taxed the ingenuity of the American inventor. The initial cost of each apparatus and of its proportion of the connecting lines is not a very formidable matter, nor would the cost of use be at all prohibitory to small users if means could be devised to divide it pro-rata among them, in proportion to the use, but how to do this without entailing other heavy expenses is as yet by no means clear. The actual cost of providing exchange service, under the conditions which at present appear to be essential, is very great, and it is at present difficult to imagine how it can be materially reduced. Nevertheless, we venture to express the opinion that it will ultimately be done.

In a paper read before the Northwestern Electrical Association, Mr. A. D. Page contends that the only practical method of maintaining the average candle-power of electric lamps operated from a central station at a point which will be satisfactory to customers, or on a competitive basis with other modes of lighting, is to keep records of the average life of the lamps employed, where free renewals are furnished, and to remove and destroy all lamps which become dim, thus keeping the average life down to whatever constant has been determined upon as the most advantageous under local conditions. It is of course very poor economy for the customer who pays for his current on a meter basis, and buys his own lamps as he thinks he needs them, to continue the use of lamps when they are not giving more than 50 per cent. of their initial candle-power, but, as Mr. Page points out, an attempt to assure him that his lamps are giving but half the candle-power they should do, coupled with an offer to sell him new ones at 50 or 60 cents each, is not likely to remedy the difficulty. Some central stations are now selling lamps at actual cost, and at the same time endeavoring to convince their consumers that only by a liberal use of new lamps can they insure the maximum amount of light for a given expenditure. This is certainly the most rational plan of procedure, inasmuch as the profit on the sale of lamps is a very small matter compared with the sale of current and with the better quality of illumination furnished. This plan has the further advantage that, without dictating to its customers, a company may virtually control the kind of lamps which are used on its circuits. Mr. Page holds that at the present price of lamps, where fuel is high, it pays best to use high-economy lamps, destroying them at a point which shall insure satisfaction as to average light.

Professor G. D. Shepardson recently read a paper before a representative gathering of practical electrical men in which he made a forcible plea in behalf of technical education. He said that our technical schools are more and more insisting upon the fact that success in the engineering profession is only attainable by hard and unceasing work; that the student must seek to temper his theory with practice and govern his practice by theory. Students are now urged to spend their summer vacations in electrical factories, repair-shops, electric-light and -railway stations, in wiring, or in whatever way they may have an opportunity to gain experience in practical work. If circumstances are favorable, they are urged to continue their workshop experience through a full year before returning to finally complete their technical course. In many instances, after graduation, students have found permanent and remunerative employment in concerns with which they have spent their vacations.

Professor Shepardson also took occasion to point out what he regarded as the true relation between the technical schools and the men who are engaged in the various electrical industries. The schools, he said, should aim to educate their pupils in such a way as to raise the general standard of construction and repair work; to assist in the development of new industries, and generally to be of service wherever located; they should offer the facilities of their libraries and laboratories for original investigation and research, and for expert determinations of efficiency, strength of materials, and the like. In return, those engaged in the electrical industries should encourage the schools by encouraging the graduates, and should make use of these institutions as employment bureaus. They may also in many instances greatly aid schools by sending to them samples and specimens, the results of peculiar accidents; exhibits from their scrap-heaps showing the effects of use or of abuse upon different materials and apparatus; pieces of discarded apparatus with reasons for disuse; specimens of historical interest, showing the process of evolution in machine design, etc. These all appear to be excellent suggestions, and, we have no doubt, will bear valuable fruit.

THE design and construction of small electric-lighting plants for isolated country mansions, factories, and the like has hitherto received less attention in America than in England, where installations of this character have become quite the fashion and furnish an agreeable and profitable field of employment for a considerable number of enterprising contractors. The *Electrical World* has published drawings and specifications of a plant adapted to supply fifty 16-candle-power incandescent lamps, which is operated by a 4 horse-power gas-engine. The dynamo is wound for a potential of 135 volts, and is employed to charge a storage-battery of 53 cells. The normal rate of charge and discharge of the cells is 12 amperes, and the battery has a maximum capacity of 140 ampere-hours. When fully charged, it will supply forty 16 candle-power lamps for four hours. The weight of each cell, including the solution, is about 65 pounds. An automatic switch is used, which is so constructed that whenever the electromotive force of the battery exceeds that of the dynamo, the circuit is held open, but under the reverse conditions it is instantly closed. Obviously, in places where gas is not available, the automatic petroleum engine, which is now to be had in great perfection, would serve the same purpose. In fact, it would seem as if, with a good automatic engine, the costly and troublesome storage-battery might safely be dispensed with altogether, in a plant of this kind. It is a field well worth the attention of our electrical inventors and manufacturers.

A GREAT deal of unavailing ingenuity has been expended by amateur inventors in past years, in the effort to produce an effective repeater for long-distance telephone work. We are pleased to learn, from a letter published in the *Electrical World*, that a substantial advance has been made in the direction of the long-sought-for goal. This correspondent writes that after a great many experiments he finally succeeded in producing an instrument of which it could truthfully be said that "it was just as easy to carry on a conversation over a long line with the instrument in circuit as without it." We advise the writer to rest content with this triumph; it is not likely to be soon surpassed, either by himself or any one else.

THE question of submarine-cable communication between the Dominion of Canada and the Australian and New Zealand colonies by way of the Pacific ocean received serious consideration at the recent Intercolonial conference at Ottawa. Mr. Alexander Siemens presented facts and figures intended to demonstrate the feasibility of the project, both technically and commercially. The line recommended by him is in four sections, extending from Vancouver, British Columbia, to Ahaipapa Bay, New Zealand, touching at three intermediate islands, and having a total length of 7340 nautical miles. The total estimated cost of the enterprise is £2,000,000, while the annual cost of maintenance and operation is put at about £120,000. Mr. Siemens thinks that if the company met with average success, it might be expected to earn say £30 per mile per annum, which is less than the average earnings of all the submarine companies since 1887. In this case the annual income would be £220,000 per annum. According to the statement of Sir John Pender, the cable traffic to the Australian colonies by the existing lines is worth £209,628 net per annum. One of the existing Atlantic companies is said to earn an average of £50 per mile per year. The laying of a Pacific cable is of course only a question of time, and it is also probably only a question of time when it will prove fairly remunerative.

MR. H. WARD LEONARD, who has devoted a good deal of attention to the problem of the industrial applications of electrical heating, has recently made an improvement in apparatus for this purpose, which consists in giving the resisting conductor a thin coat of fireproof insulation and then casting a body of metal around it. Although the insulating material is necessarily a poor conductor of heat, yet by reason of its thinness it offers but little resistance to the transfer of heat to the metal. Mr. Leonard considers that where the cost of energy per horse-power per annum does not exceed that of two tons of good coal, electric heating can now compete, on the score of economy alone, with fuel burned in the ordinary manner. Of course there are a large number of special applications of electric heat in which the condition of comparative economy has but little weight, in comparison with convenience and utility.

IN a paper read before the Northwestern Electrical Association, Mr. B. J. Arnold gave some interesting figures showing the economy of operation of fifteen large direct-current electric central stations in different parts of the United States. The average cost per ton of coal was $2.28; watt-hours produced per pound of coal, 81.5; cost of coal per kilowatt-hour, $0.0146; cost of other expenses per kilowatt-hour, $0.0465, and total cost per kilowatt-hour of current delivered to the consumer, $0.0620. A large American alternating station having an output of 2,090,000 watt-hours per day, pays $3 per ton for coal, and, running 9½ hours per day, produces 52 watt-hours per pound of coal, at a cost of coal per kilowatt-hour, $0.0289, —almost twice as much as the average of the fifteen direct-current stations. The alternating station at Cologne, Germany, shows 71 watt-hours per pound of coal. This discrepancy, however, is in part to be accounted for by the much greater average distance to which the current is transmitted by the alternating system.

Mr. Arnold expresses the opinion that while Europeans have recognized the advantages attending the use of storage-batteries as auxiliaries in central-station work, we in America have been slow to see this advantage. There is of late, however, a tendency apparent among American engineers and station-managers to look with more favor upon this adjunct, and, as there are many instances in which a battery plant as an auxiliary can be made to pay handsomely, it is probable that within the next five years we shall see many such plants installed.

ONE of the electric cars of the North Hudson County railroad of New Jersey, has been experimentally equipped with a small auxiliary storage-battery which is charged from the main line, and is automatically switched into connection with the car-lamps whenever the main current is interrupted,—as by detaching the trolley from the wire,—but is disconnected from the lamps when the main current is restored. It would seem that a device of this sort, if not too costly, might often be of considerable service.

THE power-house for supplying electricity to operate the Baltimore Belt tunnel will be a brick and stone building having an area of 69×300 feet. The capacity of the dynamo and engine equipment will be 12,000 horse-power. Work on the building has already commenced and it will be pushed to completion as rapidly as possible. The trains of the Baltimore and Ohio railroad are to be hauled through the tunnel, steam-locomotives and all, by huge electric motors.

THE record of serious accidents and deaths to passengers in electric street-cars, arising from collisions and derailments, is becoming a somewhat alarming one. Half a dozen such casualties were reported in the list for June, published in the *Railroad Gazette.* The frequent determination of the managers and exploiters of street-railway lines to cross steam-railway tracks at grade in large towns, in which they are too often abetted by the local municipal authorities and even by the courts, is the real cause of most of these accidents, but it will probably be necessary to slaughter a great many innocent persons before anything effectual will be done about it.

AN electric railway for both passenger and freight traffic is now in successful operation between the towns of Wilmerding and McKeesport, in western Pennsylvania. The line is about four miles in length and passes over a mountain 1200 feet high, encountering some grades as steep as 12 per cent. with many sharp curves. Each car is equipped with two 30-horse-power motors. A conveniently-situated coal-mine made it possible to locate the power-house and car-barn midway on the line, on a plateau at the top of the mountain, and a picnic ground has also been established near by, which is expected to become a place of pleasure-resort for the citizens of both towns, and thereby add largely to the revenues of the road. The water used in the boilers is pumped from the foot of the mountain by an electric motor.

THE Illinois Central railroad is experimenting with an electrical apparatus for killing grass and weeds. A flat-car carries a dynamo-plant and a sort of brush consisting of a fringe of copper wires depending from its front end, which is made long enough to cover the width of the track and extend to the end of the ties. A pressure of 10,000 volts, produced by a step-up converter, was found to be sufficient to do the work effectively, Steam and brine have both been heretofore tried for the purpose, but with less satisfactory results than those which have attended the use of electricity.

A PROJECT is under consideration for supplying San Francisco with electric power brought from Clear lake, a distance of about 75 miles, at which point it is stated that it is possible to render available about 30,000 horse-power. It is estimated that by employing a pressure of 25,000 volts, about 20,000 electrical horse-power may be delivered in San Francisco. The estimated cost of the hydraulic plant is $1,000,000 and that of the electric plant, $3,000,000. Owing to the high price of fuel, energy is worth about $10 per horse-power per month in that city. San Francisco, with its 300,000 inhabitants, in spite of being thus handicapped by the high price of fuel, has become the ninth manufacturing city in the Union. It now uses about 60,000 horse-power. If the Niagara undertaking turns out successfully it is probable that no time will be lost in putting the California project under construction. Apparently the only critical point is as to the practicability of employing so high a pressure as 25,000 volts, and this is likely to be settled affirmatively at an early day.

THE little town of Union, Mo., has a system comprising 250 16-candle-power commercial electric lamps, and 16 32-candle-power street lamps, which are supplied from an alternating station at Washington, ten miles distant. By means of raising and reducing converters, the transmission is effected over a pair of No. 8 copper wires at a pressure of 4000 volts. There are many other places in the country where this plan apparently might be carried out with great advantage.

IT may be worth while to note that a simple tangent galvanometer, which will give the value of an electric current directly in ampere readings, may be made by employing a coil of five convolutions of wire, which should be of a thickness not less than No. 8 American gage. The mean radius of the coil must be 6.72 inches for New York and Chicago; 6.37 inches for Philadelphia, and for any other place the coil must have a radius inversely proportional to the intensity of the horizontal component of the earth's magnetic force at that place. When traversed by one ampere of current, such a coil will deflect a magnetic needle exactly 45°, and hence the tangents of all the angles must correspond directly to the number of amperes flowing in the circuit.

WE would suggest to the managers of some of our electrical journals that, while the publication of immense scratchy "illustrations" which cover pages of valuable space and fail to illustrate anything beyond the bad taste of their designer, may be open to justifiable criticism, the case is not much better when photo-engravings of complicated machines, and still worse, of graphic diagrams containing mechanical curves, are so severely "ensmalled" that the reference letters and explanatory legends cannot be made out, even with the aid of a reading-glass. We trust this intimation may be sufficient to ensure a reform in this particular.

THE *Electrical Engineer* publishes an illustrated description of what it terms "the smallest electric railway in the world." This outfit has been built for the delectation of a youth of seven summers at Bellwood, Minn., who is his own general manager and motorman. The track is 600 feet long and 14 inches gage, and is equipped with a motor-car and two trailers. The engine is a 2 horse-power petroleum motor, and the power-house is provided with a complete equipment of station instruments. This is a characteristic example of the way Young America is sometimes taught to do things.

FOR two years past the Cœur d'Alene Mining Co. of Idaho have been operating the pumps and air-compressors of the Poorman mine by electricity, and the results show a saving of $100 per day in the item of fuel alone over the steam-machinery formerly used. The power-house is situated 1½ miles from the mine, the generators being operated by Pelton water-wheels under 800 feet head. The concentrator and compressor are each driven by a 175 kilowatt motor, while a 150 kilowatt motor serves to operate the mine pump, raising 500 gallons of water per minute to a height of 500 feet. One great advantage attending the use of electric power is stated to be the avoidance of the destructive effects of steam on the timbering of the shafts.

A POWER-BUILDING designed for the occupancy of 64 different small manufacturing concerns is under construction at Pittsburgh, Pa., in which no belting, shafting, or pulleys will be used. A complete system of electric motors will be installed on each floor, the power for which will be supplied by a 250 horse-power steam-driven electric generator located in the basement.

THE telephone line connecting the city of Vancouver, B. C., with the waterworks dam is carried across the mouth of the harbor, a distance of 1200 feet, in an insulated cable inside the water-pipe. Owing to the immense force of the ebbing and flowing tide, no independent cable could be made to last more than a few weeks. The present plan has proved to be entirely satisfactory.

ARCHITECTURE

Conducted by Barr Ferree.

WHILE architects in America are devoting their bodies and souls to the study of French architecture, especially in its Renaissance phases, architects in England are giving unusual attention to the study of English monuments. The tendency of American architectural thought is such that contemporary British work is almost entirely unappreciated in America, which bids fair, almost, to become more French than France. An important and interesting indication of the renewed study of English monuments by Englishmen is the number of works on English architecture that have recently appeared in England. The most important of these is undoubtedly the splendid work of Mr. Gotch, "Architecture of the Renaissance in England." A less pretentious work, not by an architect, and intended to reach the general public, or the employers of the architects, as its author constantly remarks, is Mr. Loftie's "Inigo Jones and Christopher Wren."* Though addressed to the public at large, the architect will find much to interest him in the book. It is pleasantly written by an accomplished writer, who displays very considerable earnestness in his work, who seeks to establish more than he can accomplish, and who has failed to produce an elaborated or even satisfactory study of the work of the two notable architects whose names give title to his book. As a sketch of the rise and decline of modern architecture in England the work is fairly satisfactory, but of his eight chapters only one is devoted to Jones and but two to Wren, the remaining portions being devoted to the state of architecture in England before Jones and to the successors of Wren. In a measure the subject demanded this treatment. The work of Jones and of Wren, while entirely distinct in itself, marked an epoch in the general history of English architecture. Standing alone and apart as both did, in a certain sense, they were still products of causes, rather than distinctive men who, by the mere force of their genius, impressed a new style upon England. Wren, indeed, left English architecture in a state totally transformed from that in which he found it, but it was already moving in the direction in which he worked, though had it not been for the splendor of his genius and the force of his individuality the evolution of the Renaissance style in England would unquestionably have been conducted on much more laborious lines than was actually the case. In thus clearing the atmosphere of English architectural art in the thorough and effective manner that his vast genius enabled him to do, Wren performed a task of the utmost value. The architectural tendency of the fifteenth and sixteenth centuries on the continent was toward that new form we call the Renaissance. It is immaterial whether Gothic architecture had died a natural death or not, or whether it was capable of further development along lines that have never been tried. It is a fact that men were moving away from it, and though England was, in this, as in all other architectural styles, a good century behind the continent, it had the very great advantage of possessing in Wren a master spirit who was able to effect a sharp transition without any especially painful intermission.

Apart from the great service Wren did to England in emphasizing the changed conditions of architecture, his most notable work was the change he effected in church architecture. Not many years ago a great deal was heard in America about the "modern" cathedral, and Wren's great cathedral church of St. Paul was held up as the final expression of the modern church idea. In a certain sense this is true. The huge open space under the dome of St. Paul's appears, at first sight, admirably adapted for a preaching service, in contradistinction to a liturgic service for which the Gothic cathedrals were especially planned and adopted. But in order to demonstrate successfully that a church planned like St. Paul's is typically modern—the only type, in fact, to be followed in a modern church building—it is necessary to show, first, that the liturgic service is a thing of the past, and, secondly, that a church so planned is entirely satisfactory for a preaching service. As a matter of fact, neither of these propositions can be shown to be true. If we take the church of England, for whose service St. Paul's was nominally constructed (though Mr. Loftie shows that Wren was forced to keep in mind its possible reversion to the Roman Catholic faith) it must be at once admitted that the liturgic service shows no sign of decay,—a point well emphasized in St. Paul's itself by the erection of a large and costly *reredos* within the last few years. And every one who has been privileged to attend a service at the cathedral is fully aware that it is one of the most difficult churches in the world in which to hear, and that it is impossible to hear the voice of the preacher save from points very near the pulpit. It would seem, therefore, that no reason at all exists for taking St. Paul's as a type for "modern" churches. It is true there are now many non-liturgic denominations, and many churches in which the sermon is still, and perhaps always will be, the most important part of the service. For such denominations an amphitheatrical church is doubtless better suited than the older forms of the Gothic. But until it can be shown that such a service is the only genuinely modern one, the idea of St. Paul's as the typical modern church must be given up. The history of the religious development of the present century has certainly not been such as to give foundation for any such belief. It is *a* modern type of church building, it must be granted, but certainly not *the* type. The question is scarcely raised in this form in Mr. Loftie's interesting volume, but it is suggested by the current applications given to Wren's plan.

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* *Inigo Jones and Wren, or the Rise and Decline of Modern Architecture in England.* By W. J. Loftie. London and New York: 1893.

THE Home Insurance building has now been exhibited on lower Broadway, New York, for a sufficient length of time to enable the inhabitants of that city and its numerous visitors to become thoroughly accustomed to it. Like many other recent buildings, it has its good and bad points. Its architects deserve credit for not having attempted too much, and for embodying in their façade several excellent ideas which, while very good in themselves, have not been carried out in the happiest manner. In the first place, they started out with the intention of dividing the façade into three well-defined portions,—a base, a superstructure, and a top. This they have done, despite the fact that the openings in the base have no relation to those of the superstructure. They deserve some credit also, for giving this lower portion some ornamental character. They have not put all their ornament at the top, where it is practically invisible, but have used it in the lower portion, where it may be seen. The detail itself is too small, and in too low relief, to have sufficient value, but the idea of its distribution is a good one. The central portion is further to be commended for its severity. In a fifteen-story building it is the worst possible thing to spread the ornament all over it, though such a system is not strange in New York. But the architects of this building have been brave enough to boldly recognize this fact and their design gains measurably by it. Unfortunately, the vertical lines of the building are repressed to their utmost limit. Throughout the whole front there is no line extending through more than two stories, and in the superstructure where they would most naturally occur there are none at all. In fact, every effort has been made to emphasize the horizontal lines by carrying string-courses across the front over and below the windows and in emphasizing the window sills. It is true enough that the force of these lines is somewhat weakened by their slight projection, and the uniform white surface of the building, but they are unmistakably present, and a most valuable element in a vertical design is lost. The upper portion is scarcely as happy in treatment as the lower. The *loggia* at the top gives some relief, but is scarcely happy in its effect. There is no proper cornice to the building, either in connection with the *loggia* or above it, and this feature is forced to act in that capacity, a work to which it is scarcely adequate. The detail here is also wanting in relief and is almost lost. The gabled roof is an ingenious idea, though there is no reason at all for bringing a high narrow building to a point at the top, and the silhouette is far from good. Yet there is a great deal of satisfaction in the brilliant red tiles with which this wedge is covered. Looking at the building from the steps of the elevated railroad at the Bridge entrance, one sees the most patriotic building in New York. The dazzling whiteness of the walls, and the scarcely less brilliant red of the roof, forms, with the bright sky that often hangs over New York, a glorious monument to the national colors of our country. And it is more appropriate from the close proximity to the City Hall, over which the flags of foreign nations seem to float oftener than the flag of the United States. It is a patriotic object-lesson of no small value, and derives a special interest from having being taught by architects with well-known leanings towards Tammany Hall. The patriotism of that noble body was never more thoroughly or appropriately illustrated than in this building.

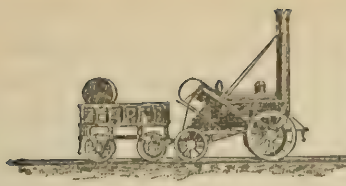
AMONG the most atrocious buildings in New York (and it is now necessary to visit the metropolis to see what very bad things can be done in architecture,—it used to be necessary to go to Philadelphia) the Downing building takes easy precedence. The erection of monstrosities is proceeding at so rapid a rate in New York that doubtless it will not long retain its preëminence in this respect, but meanwhile it affords food for ample and thoughtful study. The Downing building is fourteen stories high and is apparently constructed entirely of iron. It should, therefore, afford the utmost delight to those constructional purists who maintain that the construction must, at all hazards, appear in the exterior. Unfortunately the material is only apparently shown here, for while the building is supported by a steel cage, the front of it was filled in with brick work, and an alleged cast-iron decoration (?) or surfacing placed over it. The building is intended for offices and manufacturing purposes and the front is composed almost wholly of windows. It is true that there is a narrow metal line on either side of the front, and two others dividing the façade into three equal portions, running clear to the top, though interrupted at every floor. But these are lines only, with scarcely width enough to give them structural value, and entirely worthless from the standpoint of design. The great height of the building renders it easily one of the most conspicuous in the lower part of New York, thus emphasizing the utter contempt its owners have manifested for architectural art. No other recent building of this size in New York has been carried out with so open a disregard of architectural proprieties. Even the commercialism of the building is unnecessarily emphasized, while the cast-iron surfacing with which it is covered is a reversion to a style of design that every one must have long since hoped forgotten. That it should have been revived in this year of grace, and that any one could be found who would use it for a business investment, is very sad indeed, and shows very clearly that even in circles closely allied to architecture there is amplest room for the greatest improvement. We notice with some astonishment that this building is advertised in the daily press of New York as the "handsomest business building" in New York. With it is coupled that miracle of horrors, the Bennett building, which would be the worst cast-iron building in the world were it not for the Downing structure. There must, therefore, live somewhere in the metropolis a soul to whom these amazing vagaries in cast-iron are the furtherest expression of architectural art. As we have no objection to giving a friendly hint, even to those from whom we differ, we would suggest that he could doubtless obtain a handsome honorarium from some enterprising dime-museum manager. Ten cents would certainly be a very small sum to pay to see any one who could say in public that the art of these two buildings was good and pleasing in his eyes.

HERE they are: Mr. John P. Benson, Mr. Albert L. Brockway, Mr. William B. Bigelow, Mr. Charles L. Berg, Mr. William A. Boring (first Frenchite, president), Mr. John M. Carrère, Mr. George Cary, Mr. Pearce Casey, Mr. Walter B. Chambers (secretary), Mr. Walter Cook, Mr. Randolph Coolidge, Mr. Ernest Flagg, Mr. A. D. F. Hamlin (adjunct professor), Mr. Henry S. Hunnewell, Mr. Richard M. Hunt, Mr. Richard H. Hunt (corresponding secretary), Mr. Thomas Hastings, Mr. Abner T. Haydel, Mr. John G. Howard, Mr. Edward Howe, Mr. E. L. Masqueray, Mr. Joseph H. McGuire, Mr. Charles F. McKim (vice-president), Mr. Grenville T. Snelling (instructor), Mr. John Stewardson, Mr. Edgar V. Seeler (assistant professor), Mr. S. B. T. Trowbridge, Mr. Alfred Thorp, Mr. Edward L. Tilton, Mr. Whitney Warren.

These gentlemen are the practising architects who are members of the Society of Beaux-Arts Architects, New York. They are the only real and genuine Frenchites in America. With one conspicuous exception they are all guaranteed to supply designs in the latest Paris fashion. Any one changing his abode for a more fashionably-designed residence is cordially invited to lose no time in conferring with some one of them. Business is, perhaps, not so plentiful now as it might be, and, while no reduction can be made on account of slackness of trade, very special inducements can be offered in the latest importations from Paris. Absolutely genuine Parisian designs, made by their makers in Paris itself can be had in most instances if bespoken early. It will be noticed that while all the American schools of architecture are more or less under French influence, no full professor is a member of the Society, though three assistant professors are among the members. It should also be added that the list of students who have studied in Paris, but who were not regularly entered at the École des Beaux-Arts, is quite considerable and is not included in the above list. Neither are a number of draughtsmen who have not yet hung out their shingles as architects included. The Society does not yet number all the École men in America, but its membership includes the great majority of those who may be properly termed Frenchites.

THERE is no more important question before the architectural profession (except, possibly, that of education) than the formation of architectural partnerships. How shall they be constituted, and what shall be their basis? These are momentous questions, and on them many an architect has wrecked his life, and many more will do it in the future. On the face of it there would seem to be an advantage in the division of labor. Under some circumstances—under many circumstances—two heads are better than one. The duties of the modern architect are so varied and complex that on general grounds a division of labor is not only desirable but absolutely necessary. But how shall it be divided? The obvious answer, a constructive member and a designing member, is far from working easy in practice. The relative functions of each are easier set down on paper than adjusted in actual practice. It will be the easiest thing in the world for the designing member to propose artistic expedients that the constructionist will pronounce impractical, unnecessary, absurd, unthinkable. On the other hand, it is quite as possible for the soul of the constructionist to be fired with artistic zeal, manifesting itself in the creation of imagined artistic devices, that the artist partner will at once recognize as only describable in the language that has, as likely as not, just been used towards himself. Nor is the case simplified when two designers form a partnership, unless the class of work be divided absolutely at the outset. In this case no conflict of opinion need be expected. But unless some such division is made the differences of opinion that may arise between two designers may become too large to be contained within the cubic area of the mutual office. And this may not only become large but acute, and it is not every nature, much less delicately artistic ones, that can stand the strain long enough to permit each man to mutually adjust himself to the limitations, peculiarities, and abilities of the other. The basis of all architectural copartnerships is mutual confidence. A radical division of construction and design, or of classes of structures, is of no value unless there goes with it a large supply of mutual confidence, that is available on all occasions, that is never wanting in strength and honesty, and that can absolutely be depended on. The question is not so much what each man can do, but how far each is willing to trust the other, and how long.

VISITORS to the World's Columbian Exposition will remember the very handsome exhibit in the English section of Messrs. Hampton & Sons, whose reduced model of the Banqueting Hall at Hatfield House attracted a great deal of deserved attention. We are indebted to this firm for their book of "Designs for Furniture and Decorations for Complete House Furnishing," which is one of the most costly and splendid trade publications we have seen. Illustrated with collotype reproductions of interiors, with colored plates of rugs, hangings, china, and other household fixtures, and with nearly 2000 photographic reproductions of furniture, it forms a most useful and convenient handbook to contemporary British furniture. Dealing, as it does, with every article of domestic use, it necessarily includes many subjects that can scarcely be admitted within the realm of the artistic; but the book is extremely interesting. Many of the designs shown are of real excellence and originality and the whole may be most profitably studied. A work like this, which deals with all sorts of furniture, is intensely suggestive of the multiform requirements of modern domestic life. Every year, almost every day, is marked by the addition of new articles of furniture, sometimes useful, sometimes ornamental, but generally characterized by an artistic feeling that is eloquent testimony to the prevailing note of the artistic in current life. It is true this is very far from being well expressed in many instances, and very costly houses are even to-day fitted up in a gorgeous manner quite incompatible with the canons of good taste. But these instances are becoming rarer and rarer every day. The modern decorator is constantly extending his practice, and the best architects are rapidly creating a permanent demand for his work. Furniture is one of the easiest things in which to sin artistically,—not so much because it is cheap, but because the furniture and decoration of one style is easily replaced by that of another. Probably no people have more frequently sinned in this respect than the Americans, but we know of no people that can faultlessly declaim against them. The rapid increase of wealth in America has, of course, hastened any development of this tendency that might have become manifested. It is, perhaps, difficult to escape from such consequences, but opportunities of doing so are becoming less rare every day. At all events it is a distinct mark of progress when the shoddy is thrust out by the artistic; the reverse process may be witnessed only in periods of deep degradation.



RAILWAYS

Conducted by Thomas L. Greene.

ON the first of July a few more defaults in bond interest were made, complicating in some cases the existing conditions and in others adding to the already long list of railways which have confessed themselves bankrupt. More than one-quarter of the railway mileage of the United States is now operated by the courts and an equal proportion of our entire railway capital is thus discredited. "Bradstreet's" reports the percentage of commercial failures at less than 1 per cent. of the number of merchants and corporations in business. While, of course, we cannot compare the statistics of so large a corporation as a railway with the statistics of failures among trades-people large and small, yet it is manifest that so great a disproportion should have the most careful consideration at the hands of those who are hoping for a return of prosperity. The prevailing depression, of course, will account for a certain number of failures in the transportation business as in other lines, but it seems that there must have been something wrong with the situation when dullness could throw into bankruptcy so large a part as one-quarter of our railways. Probably transportation is the largest single industry in the United States, with the exception of agriculture. Our railways employ nearly a million of men, while many large and small establishments depend upon the orders of the railways for their trade. The money disbursed by the transportation interests in wages and in purchases of material and supplies is of great importance to the whole country. If, therefore, we as a people wish for such a reasonable prosperity among the railways as will help forward all business interests, we should consider whether the charges of the railways are not now too low to support the capital necessary for the safe and speedy transportation of passengers and freight. There is no single question before our business men of greater importance than this. If our rail carriers cannot earn a fair return upon the capital, they cannot buy supplies or extend their facilities or even give good service to the community.

The reform most urgently needed is such a modification of the interstate commerce law as will permit the railways to pool their earnings and thus to maintain the tariff rates which, as everybody knows, are not adhered to. Rate-cutting brings with it two great evils. It has diminished the earnings of all the carriers below what is reasonable, until we see the present unfortunate condition of things as a direct result. On the other hand, rate-cutting brings about that worst of discriminations,—the discrimination between persons. If one of two trades-people gets a much lower rate on his products than the other, the latter is sure in time to be forced to the wall. Just how far the principles of "wholesale" and "retail" trade should apply to transportation is a disputed question, but no matter what arguments there may be in behalf of the large firm or the large establishment, such differences certainly ought to be stated openly so that every one may know just what the transportation charges are. No doubt the difference between the rates charged one merchant and those charged another, or between those charged one manufacturer and another, under the present cutting is greater than any theory of wholesale and retail dealing would favor as an open policy. Nor do we need to fear any extortion on the part of the carriers if allowed to pool. Commercial conditions in the United States are set in favor of low charges. Our great river, lake, and canal systems of water transportation are in themselves enough to limit the rail charges in any event. To this may be added the fact that the traffic now moving is carried from place to place on a slender margin of profit to the producer. If all the possible profit were taken away by an advance in freight-charges the traffic would cease to move and the railways as well as the manufacturers would lose their business. Enlightened selfishness, therefore, may be relied upon to keep the railways from committing a blunder which would destroy their own traffic.

Only 500 miles of new railroad, approximately, were laid in the United States during the first six months of the present year. Compared with the previous records this is an abnormally small addition; not enough, indeed, for the growing needs of our people in normal times. No doubt this small mileage built thus far in 1894, together with the restricted use of iron in other departments, is one reason for the decline in the production of pig-iron. The report of the American Iron and Steel Association shows the total production of pig-iron for the first six months of the current year to have been 2,717,983 gross tons of 2240 pounds. In the second half of 1893 the production was 2,561,581 tons, but in the first half of 1893 the record shows an output of 4,562,918 tons, thus showing a very heavy decline for the second half of 1894. What this means may be seen from a brief table of output since 1886:

Years.	Gross Tons.
1886	5,683,329
1887	6,417,148
1888	6,489,738
1889	7,603,642
1890	9,202,703
1891	8,279,870
1892	9,157,000
1893	7,124,502

If now we take the total production from July 1, 1893, to June 30, 1894, we find that the product, 5,279,567 tons, is the smallest since 1885. As contrasted with the years since 1890 the falling-off in pig-iron production is very large, and shows how great is the stagnation in general business and among the railways. The production of the next six months is expected to show a slight increase, according to the *Iron Age*, but it is not pleasant to read that on June 30 only 108 stacks, including all kinds of fuel, were blowing in the United States, while no fewer than 408 stacks were idle. Better rates for the railways would do much to help the iron trade out of this "slough of despond."

In connection with the subject of cut rates is the question of the payment by the carriers of the debts thus agreed upon,—in other words, the payment of rebates. The disclosures made in Atchison affairs have created a profound sensation among investors both in Europe and in the United States. According to the public statements the net earnings of this company have been greatly overstated since the reorganization of 1889, partly because the rebates paid by the company were not deducted from the gross earnings, as they should have been. For the system of rebates the public must bear its share of responsibility. In their national and state laws they practically ask the railways to compete keenly with one another, while at the same time maintaining their published tariffs,—two things which destroy each other. No doubt the roads are more or less guilty of paying rebates. To stop the practice is impossible without a removal of the cause; but in the Atchison case the complaint goes further and asserts that the money thus paid was not properly accounted for, so that the reported earnings of that company have been for years overstated. Thus confidence in American bonds and stocks has received another blow and the business recovery, as far as the railways are concerned, another setback. This is greatly to be regretted, because unemployed men and unemployed factories are alike waiting for the revival of business on the railways to secure expected work. But this revival cannot come so long as the investor is led by such disclosures as these of the Atchison to fear that he will lose his money.

The Atchison disclosures raise another point. Railway bookkeeping as an art has not progressed with the increases in the size of the systems and the amount of traffic carried. An instance of a possible reform is in the profit and loss account. One railway prints what it calls a profit and loss account in its report, but when looked at closely this account is found to be an income account and nothing else, since it pretends to give only the results of the operation of the road for the fiscal year covered by the report. Another first-class road two years ago charged off to profit and loss some old equipment, although the item called by this name was merely a balance between the debit and credit sides of the general balance-sheet. A large system should have an income account and also a profit and loss account. The former should show the results from operation for the year; the latter should gather together all the items from year to year so that, by grouping these, the stockholder and bondholder may be able to tell just what has become of the road's money. A profit and loss account in the true sense is kept by the Northern Pacific Railroad Company, although not given in sufficient detail in the printed reports. If more particulars had been stated the stockholders of the Northern Pacific would have seen at a glance just how much of their money had gone to pay for losses on the roads purchased or leased in order to form the Northern Pacific system. Mr. Stephen Little, who examined the Atchison accounts for the reorganization committee, is comptroller for the Denver and Rio Grande railroad and annually presents in the reports of that company statements of accounts which are models of railway bookkeeping. In these reports the profit and loss account is properly handled.

ONE matter growing out of the Pullman strike deserves discussion, and that is the great length to which our railroad companies have gone in furnishing luxurious fittings for their drawing-room-cars, sleeping-cars, and even ordinary coaches. It has been assumed that the traveling public wish to journey by rail in cars upon which the utmost amount of money has been lavished in decorations. Let any reader, the next time he enters a Pullman or Wagner car, note the costly finish which he will find throughout the car. No doubt one thing which has prevented a reduction in drawing-room fares has been the increasing cost of these cars. Some of our newer sleeping-cars are reported to have cost $25,000 or $30,000 each. Nothing is clearer than that equally good accommodations could be afforded for the traveling public in cars costing but half these sums, because not so finely finished with frescoes or embossed work. The effect of this misplaced elegance in our drawing-room-cars has been to lead the railway companies into competition with each other in more expensive fittings for day coaches also. Our passenger equipment, generally speaking, surpasses in finish and elegance the homes of the majority of those who ride in them. Comfortable seats are indeed a necessity and so too is the often neglected matter of good lighting, but when we get beyond these items of necessity there is a large room for economy in the amount of money which the railway companies have lately been spending in mere ornament. It would be better for all concerned, for both the drawing-room-car companies and the railways, to build their cars and coaches hereafter on a more simple pattern, dispensing with the mere luxury of decoration.

MR. HENRY C. THOMPSON read an interesting paper recently before the Civil Engineers' Club of Cleveland on the improvements of grades versus increase in weights of locomotives. Broadly speaking, it may be said that the modern railway problem consists in hauling the largest possible load of freight from place to place. With the constant fall in the average rate of transportation the pressure upon the railways for some counterbalancing economy has been very great. This economy the railroads find in the increased lading of the average freight-trains. With most railways this object has been achieved by increasing the weight of locomotives, whereby longer trains can be hauled over each division. This, in turn, has involved a very large expenditure of money for stronger bridges, better road-bed, better cars, and more substantial work generally.

The Chesapeake and Ohio railway is an excellent example of the good effects to be obtained by this policy. Mr. Thompson presents figures to show, however, that the cost of improving the grades on a railroad is about the same as the cost of increasing the weight of locomotives, added to the indirect cost of strengthening the bridges and in other ways bringing up the track so that it may bear the heavier engine-train. Mr. Thompson's conclusion is:

> The foregoing figures indicate that it is true economy, in providing for increase of traffic, to improve the grades of a road rather than to increase the weight of its locomotives; for, although the cost of the improvement is the same in either case, we see that, at the end of the fifteen years assumed, the improvements in the grades remain as a permanent betterment for all time, while the expenditure on increasing the weights of the locomotives must be repeated every fifteen years.

Of course it is presupposed that the character of the country will allow of a choice, and where this is so the experience of the Lake Shore and Michigan Southern, in its policy of reducing grades rather than increasing the weight of engines, bears out Mr. Thompson's views. He believes that where it is impossible to effect a satisfactory revision of grades at reasonable cost it is better to use helpers rather than to rely upon heavy engines for the whole road. No positive rule can be laid down upon this subject, but Mr. Thompson's paper deserves the consideration of all those interested in the problem of increasing train-loads.

SEVERAL railways, notably the Illinois Central, Denver and Rio Grande, and the Chesapeake and Ohio have issued circulars containing the thanks of the board of Directors to the employés who stayed faithfully by the interests of the company during the late strike. This is a graceful compliment and one thoroughly deserved, No one knows better than he who is in the railway service what pluck it requires for an employé to stand fast by the company when his comrades, rightly or wrongly, are going out on strike. To be called a "scab" and abused with all the epithets in the repertory is but a beginning of his trouble. He is in real and daily danger of assault and perhaps serious injury, while possibly he may lose even his life. Under these circumstances the railways which have been in the thick of it may well compliment their steadfast employés openly. As a rule men should not be specially rewarded merely for doing their duty, but the present case is exceptional. On this account some of the stockholders of these companies are willing that some more substantial recognition of the service of the employés should be made, but the difficulty is that the railways concerned have no extra profits which they might be expected to divide with their men. Nevertheless it is reasonably certain that the loyal employés will individually receive such consideration from the railways as will in their individual cases make up the equivalent of a money reward. Such public expressions on the part of railway managers tend to promote good feeling between officers and men.

THE British Board of Trade's return on accidents shows that for the first three months of this year not a single passenger in Great Britain was killed and of employés only one. It is not altogether pleasant to note how greatly the English railways excel our own in this matter of safety. There are indeed causes for the greater number of accidents proportionately in the United States, for safety after all is a commercial thing and has its price. There is no doubt, for example, that some of our most serious accidents would be avoided if we could eliminate the grade crossing, for the crossing of steam-railway tracks by wagons and by trolley-cars affords chances for disaster which no gates can always prevent. Besides that, in the majority of country crossings there is little protection, even a flagman often being conspicuous by his absence. Yet to put a railway track under or over all common roads or streets—a thing insisted upon in England—would cost enormously. One road, the New York Central for example, reports upon its line 936 highway crossings at grade without protection, and 407 such crossings, protected by gates or flagmen. What would be the cost of the removal of these 1300 crossings and how should the expense be divided?

In the current discussion of the Nicaragua canal it is hastily assumed by some of the disputants that the Transcontinental roads, or, as they are sometimes called, the Pacific railways, are opposed to the project because it would take from them certain overland traffic which they are now carrying. But this is a superficial view of the matter. No doubt the opening of the Nicaragua canal would be attended at first by the diversion from the Transcontinental roads of a certain part of their traffic, yet even this may be easily exaggerated because the canal would compete more with the ships around the Horn than with the rail carriers; but if we look far enough in the future there is no doubt that the ultimate result of the building of the canal will be favorable to the interests of the Transcontinental railways. Anything which will increase the prosperity of a section of our country will be good for the railways which serve it. This is a broad principle which experience has many times demonstrated to be true. If some of the coarser freight hitherto taken by rail should seek the water route, the prosperity which the cheapness would bring would create other shipments for the railways on which a much greater average charge could be collected. The New York Central railroad is in daily competition with cheap boats on the Erie canal, yet the local traffic and travel which seeks this road because of the large number of prosperous cities and towns on it, is the envy of its rivals. In like manner the Lake Shore finds lake competition nearly all the way from Buffalo to Chicago, and yet here again we find this road to be considered one of the most prosperous in the United States There is no reasonable doubt that the completion of the Nicaragua canal would give to the Transcontinental railways in the long run more traffic than it would withdraw from them.

Those who are interested in the matter of lighting cars will find in the paper by Mr. M. B. Leonard, read before the Association of Railway Telegraph Superintendents, a mass of interesting facts not heretofore brought together. The conclusion of Mr. Leonard's figures is that the cost of fitting up a train with electric-lighting is about $6000. Comparing the expense per car per day of ten hours' lighting, of the three systems, and basing the illumination per car at 148.8 candle-power for this purpose, the cost is stated to have been for the last year as follows:

Pintsch gas	$0.943	per car per day.
Electric light............	.977	do.
Lewis (new) electric system	.479	do.
Oil.....................	.636	do.

The Lewis system takes the motive-power from the car-axle. Speaking of the lighting of our trains by electricity Mr. Leonard concludes: "It is evident that the lighting of our passenger-cars by electricity has passed far beyond the experimental stage. It is, therefore, greatly to be hoped that the superior advantages of electricity will ere long cause it to be utilized so largely that not only will our trains be illuminated by it, but that the weary traveler may in winter be warmed by heaters and in summer cooled by fans operated from electricity generated by the least expensive of all methods—the movement of the car itself." All of which is respectfully commended to those companies which still darken their cars by the use of oil, particularly the Manhattan Elevated railway of New York.

MINING AND METALLURGY

Conducted by Albert Williams, Jr.

ONE of the correspondents of this Department, writing about a certain comparatively unexplored tract of country as a promising place for prospecting, describes it as a locality where granite is associated with volcanic rocks, and cites a long list of similar petrographic regions which have proved rich in precious-metal ores. This raises a very interesting point in economic geology—one which has given rise to much discussion and which is of quite as much practical import as of scientific interest. It is true that there is hardly a gold- or silver-mining district, if any, where volcanic rocks do not occur either in immediate association with the ore-deposits or somewhere in the near neighborhood, as sheets or intrusive dikes of "porphyry" (andesite, trachyte, rhyolite, phonolite, diabase, basalt, etc.). This generalization holds good also as to most copper districts, and, with more exceptions, to those of lead, and especially where the ores of these base metals carry silver and gold also. These associations of granite with the eruptives are considered favorable indications by prospectors, and experience has fully sustained the belief. Both prospectors and geologists seem to have the idea, however, that in some unexplained way the volcanic masses have induced the ore-deposition; and, while it may be that in some cases the ore was derived from these rocks and also that there may be some foundation for the theory which ascribes ore-formation to electrochemical agencies brought into action by the contact of dissimilar rocks, the explanations given are not wholly satisfactory or applicable in a general sense. It seems more rational, and more comprehensible, to suppose that the two results, the ore-bearing veins and the neighboring eruptives, are merely distinct phenomena traceable to the same cause and not, as a rule, otherwise related. If there were a causal relation, then the ore would be expected to be found immediately at the contact and following it, which is seldom the case. That cause is the dynamic activity which on the one hand attended and permitted the outbursts of eruptive masses and at the same time fissured, faulted, and shattered the older rocks, thus providing the necessary channels in which ore-bearing solutions might be precipitated. It is never safe to advance or depend upon any single theory or explanation to cover all cases, for the more the study of ore-deposits progresses, the greater is shown to be their diversity; but the simple explanation now offered may be satisfactorily applied to a very large number of typical occurrences, and free us from the necessity of seeking for more abstruse and remote causes. In those instances where the ore is unquestionably derived from the "porphyry," as in the limestone-porphyry contacts, this explanation of course does not apply; nor to another familiar type of deposits, the contacts of granite with metamorphic slates, etc. But so far as it goes it seems to be a reasonable one. There are examples, as where granite is traversed by basalt dikes, where the ore certainly did not come from the barren basalt, but by lateral secretion from the granite country rock, which gives small assays; and in such cases the dikes were not the cause, but merely an accompaniment, of ore-deposition. All this does not in the least invalidate the importance of these combinations of rocks as a guide to the prospector.

IN a work on the coal-reserves of Europe and their exhaustion, Herr R. Naffe makes the following estimates of the available coal remaining in the various coal-fields, counting only seams of workable thickness not lower than 1200 meters (3925 feet): Germany, 112,000,000,000 metric tons (including some lignite); Great Britain and Ireland, 198,000,000,000 tons; France, 18,000,000,000 tons; Austria, 17,000,000,000 tons; Belgium, 15,000,000,000 tons; total for Europe, 360,000,000,000. According to these very liberal estimates there seems to be no immediate danger of a complete exhaustion of Europe's coal-resources. At the present rate of output—which, however, is certain to increase—Herr Naffe considers that it would be 800 to 1000 years before the German supply (which he considers will last the longest) is mined out. These estimates are much more favorable than those usually made, and are probably extreme. If the rapidly increasing rate of production is taken into account—and no one can prophesy how much this will increase in the future—the time of final exhaustion of European coals is very much nearer. It is within the bounds of possibility, however, that before that time is reached human ingenuity will have supplanted coal and steam by solar heat, wave and tidal power, or some other natural agency, in connection with electrical distribution of heat, power, and light.

THE problem of using low-grade crude iron and steel and scrap metal so as to produce homogeneous castings is one that has long troubled the minds of foundrymen. Mr. Walter J. May, in the *Colliery Guardian*, describes the working of a new flux, with which, he says, the commonest scrap iron has given results equal to selected metal, with both crucible and cupola work. Metal which poured like badly-mixed porridge when used in the ordinary way, after the addition of the flux became quite fluid, pouring freely and leaving the ladle clean and free from adherent metal. The castings showed a great difference, that from the unfluxed iron being very dirty and the edges faulty, while that which had the flux added was both clean and sharp. The flux contains metallic iron and sodium, and chlorids of both metals, and is in the metallic portion an alloy of iron and sodium. But even at the present reduced price of sodium such a material must be rather expensive. If that is not a prohibitory objection, and the action is as good as reported, the new flux is a material that will attract the attention of all workers in low-grade iron and steel. Scrap as bought from junk-shops and other collecting centers is composed of all classes of metal, and, while it happens that a little high-grade metal may be present, it is a pretty sure thing that plenty of poor stuff will be found. As Mr. May says, what is needed in dealing with poor pig or scrap metal is a flux that will give a ladle of clean metal in a fluid state, and this without necessitating any outlay for plant. If the new material accomplishes this at a reasonable cost it marks quite an advance in foundry practice.

A NOVEL method of retorting small quantities of gold amalgam is announced by the *Australian Mining Standard*:

> We recently asked a miner who was getting fine gold by sluicing how he saved it. "I use quicksilver," he said, "and squeeze it through calico, and when I have got the amalgam as hard as I can—" "You retort it," we said. "No, I don't and yes, I do—I don't as you mean retort, but I do as I mean it myself. I get a potato, cut off one end, and scoop out a cavity in it large enough to take my ball of amalgam. I next take a spade or piece of flat iron, and place that over the fire; and then upon that I place the potato with the cut side down. As the amalgam gets hot the quicksilver evaporates and goes all through the potato; but it can't get through the skin, and neither can it escape by the iron, for the spud is stuck to the spade. When it is done I take the spade off the fire and let it get cool, and then I have my gold in a button on the spade and my quicksilver all in fine globules in the potato. I break that potato up under water and I have all my quicksilver."

FOR detecting internal flaws in iron and steel masses Captain de Place, of Paris, has invented a system and an apparatus, called the "schiseophone," the latter consisting of a small pneumatic tapper worked by hand, and with which the metal to be tested is tapped all over. A telephone having a microphone interposed in the circuit is connected with the tapper, but is placed in a separate apartment so that the direct sounds of the taps may not disturb the listener who is in electrical connection with the other operator, and gives no sign so long as the sounds are normal, but when a false sound is heard immediately signals to the tapping operator to mark the spot. The design is not merely to detect a flaw, but to locate it.

WESTERN lead-smelting works receive for treatment almost every known ore of the precious metals, with the exception of low-grade gold-quartz. A very common type of ore treated by them consists of mixed sulphids—galena, blende, pyrite, marcasite, arsenopyrite, stibnite, etc.,—which, when present in large quantities, are roasted before smelting, but also enter raw into the furnace charge in smaller amounts. Metallurgists unfamiliar with the conditions prevailing in the far west are sometimes exercised over the loss of a number of possible by-products in the usual system of reduction, and especially on account of the zinc. It is said, for instance, that the smelters are saving lead, and giving their main attention to that while letting zinc, which has a higher market value per unit, go to waste. This is quite true of the usual system, though the "bag" process arrests part of the zinc oxid and other volatile products, and the ordinary flues catch other portions, which however are utilized very imperfectly. Now the facts are these: There are very few lead-mines in the far west which could be operated at a profit for the sake of the market value of the lead, *as lead*. There is always a demand at the smelters for heavy lead-ores, of which the Cœur d'Alene mines and a few others produce large quantities, but this demand again is not for the lead as such, that is, to turn out lead for the market, but because it is the basis of the whole smelting industry in which lead is used as a collector of the precious metals. Besides this, the lead of the far west always carries more or less silver and a little gold. Although called lead-smelting, and rightly so from the technical standpoint, it is really, and from the commercial point of view, a process for the extraction of silver and gold in which lead is used as the collector of these metals. The lead itself is a by-product. It has a market value, of course, and, after being turned into base bullion and subsequently refined, the proceeds form a large item of income. On its own account, however, very little lead would be produced west of the Joplin district of Missouri and Kansas. The base bullion, requiring not merely a softening operation but a true refining process, yields small quantities of other by-products, of which little account is made. As to zinc, so far from yielding a valuable by-product, it is regarded as a positive detriment in the lead-smelting process, and ores containing it are subject to deductions in price. The blende is also badly mixed with other volatile minerals, so that a distillation process would give an impure zinc. When the western country becomes more thickly settled, so that there is a larger local demand, and the long hauls to market are unnecessary, it is probable that the whole system of ore-reduction may be changed, and brought into something like that of Germany, where practically everything of value is worried out of the ore by an elaborate system of concentration and classification, followed by special processes for the different classes of material. Under existing circumstances this would be impracticable, as would be also any general wet process, with electrolysis. The enormous cost for additional plant, the relatively high wages, the cost of transportation of ores from mines to works and of products from works to markets, stand in the way. While it would be desirable to utilize all the numerous accessory metals and substances—zinc, antimony, arsenic, sulphur, and many others in less amount—present in the mixed ores, it must be remembered that the lead-smelting industry of the west has been developed to a very high degree of efficiency, regarded in connection with the peculiar conditions; and that even under obvious disadvantages it now leads the metallurgical practice of the world in its own sphere. To have brought the cost of smelting to within $4 per ton of neutral ore, at works to which every item of supplies—ore, fuel, flux, etc.,—has to be transported greater or less distances, and where labor is by no means cheap, is certainly a great achievement; and to do this with a technical success measured by a recovery of 95 per cent. of the silver and lead, and more of the gold, is a still greater achievement. Those who find fault with present western methods do not realize either the intricacy of the conditions or the remarkable progress that has been made.

THE loss of gold and silver in the scorification assay is a considerable, though rather an indefinite, quantity. Messrs. W. P. Mason and J. W. Bowman have been making some experiments to determine the amount of this loss, and communicate their results to the *Journal of the American Chemical Society.* From a large number of assays they found that with silver the loss by the entire process was 2.54 per cent., of which 1.99 per cent. was in cupellation and 0.55 per cent. in scorification. With gold the loss in the entire process averaged 0.87 per cent., of which 0.296 per cent. was in cupellation and 0.574 per cent. in scorification. These results show larger losses than is commonly supposed, and perhaps larger than is usual. But they serve to explain in part some of the exceptionally high records made in smelting, where the comparisons are based upon the scorification assay. It remains now for a new series of experiments to be undertaken to determine losses in the crucible assay for gold and silver. Some figures are quoted in the books, but they are not regarded as altogether reliable, and there is always the personal equation of the assayer to be taken into the account. In his new book on assaying, Mr. H. V. F. Furman advocates the determination of silver in two or more portions of the ore by scorification, and the gold in two or more portions by crucible assay. This is the Colorado practice. Most ores yield higher silver returns by scorification and higher and more uniform gold results by crucible assay. The reason stated by Mr. Furman why the crucible method gives better results on gold, is that it allows larger quantities to be taken for assay, and hence a larger gold button for weighing. Both methods can of course be made more accurate by running a number of assays and combining the buttons in parting. The claim for the remarkable delicacy of the fire assay for gold and silver still holds good, if care is taken and all sources of error are understood and proper allowance made. In ordinary work the error should not be more than half an ounce silver (and much less gold) per ton; while in delicate scientific experiments, using specially prepared litharge and micrometer measurement of buttons instead of weighing, Mr. J. S. Curtis has determined (and proved) quantities of silver down to 5 and 3 cents a ton of ore.

IN a paper recently presented before the Engineering Society of the South, Mr. A. Porter Gaines described the modern blast-furnace stack, stating that the universal construction of a modern stack is a round sheet-iron shell somewhat in the form of a truncated cone, supported at the base, which is the widest part, by columns. This shell is lined with fire-brick, having a packing space of 3 to 5 inches between the shell and the brick, which is filled with some light loamy material. The points of difference are the dimensions of this shell, the height, diameter, distance from hearth or bottom, which shall be supported, and interior shape or lines, as given by fire brick lining. The conditions governing the dimensions are chiefly the character of the stock (fuel, ore, and flux) and the volume of the blast. Modern practice is towards large outputs, and, looking to this end, the dimensions are as large as these conditions will admit. The interior shape is more or less in dispute among furnacemen. It is largely theory as to the mechanical arrangement and chemical changes that material undergoes in the stack, so necessarily it follows that there would be more or less difference as to the interior arrangement of furnace to obtain the best results. Mr. Gaines lays stress upon the fact that conditions are so different in different localities that, in his opinion, it is very questionable whether there will ever be found any specific inside lines that will give universal success. Although wonderful results have been obtained from the modern blast-furnace, both in low fuel consumption and large output, still it is far from having reached its full development. While the progress of pig-iron making may not be so rapid in the future as it has been in the past, Mr. Gaines believes that it will undoubtedly be changed materially both in construction of plant and practice.

A PLAN worthy of imitation by all mining schools situated in mining localities has been put in practice at the South Australian School of Mines. To meet the wants of prospectors and others interested in mining a "prospectors' class" has been formed, in which technical matters are avoided as much as possible, the object being solely to enable searchers to establish the presence or absence of minerals of economic value by means of the blowpipe and with such chemical tests as are available to prospectors in the field Instruction is also given regarding the rocks and associated minerals among which search may be prosecuted with the greatest hope of success.

A RECENTLY-INVENTED apparatus for burning anthracite culm consists of an automatic grate which moves sidewise under the boiler at a rate of 3½ to 5 feet per hour, carrying with it the culm, which is heated as it approaches the furnace and is completely oxidized while in it, the ashes being carried away by the movement of the grate. It is claimed that this apparatus solves the difficulties of stoking, avoidance of clinkers, and disposal of ash, while allowing perfect combustion. This is only one of a numerous class of inventions lately announced, for utilizing culm, the successful introduction of any one of which will have a most important bearing upon the anthracite industry, since nearly one-third of the anthracite mined has been and is going into the waste-dumps, where it is not merely a loss but a positive inconvenience and source of expense for handling and for dump-room. Thus far neither the various devices for burning culm under boilers, nor the different methods of briquet-making, nor the production of water-gas, however promising, have done much toward reducing the enormous waste in culm; but it is to be hoped, and may be expected with some confidence, that a successful solution of the problem will be reached before all the available anthracite is mined. The amount of thought and ingenuity that have been bestowed upon the question ought surely to accomplish something on a large practical working scale before long. It is one of the disappointments of this age of boasted economies that the culm problem was not disposed of a generation or more ago. But now there are several directions in which light is beginning to appear, and in the anthracite regions the culm is being utilized quite extensively.

AN electric auger-drill for coal-mining, lately introduced, seems to possess valuable qualities. The drill complete for bituminous mines weighs 1600 pounds, and is capable of developing from 4 to 5 horse-power at the auger (though from 2 to 2½ horse-power is the usual requirement), and has been tested to 7 or 8 horse-power without excessive strain, showing no signs of sparking or over-heating. The largest size drill, of the same pattern, with a nominal rating of 4 mechanical horse-power, is designed especially for anthracite mining, for trimming gangways, taking down roof, and for general rock-work. It is said to have drilled a 2-inch hole 6 feet deep in the hard "boney" in from two to 2½ minutes; while drilling in the coal proper a similar hole has been made in fifty seconds.

THAT must be a wonderful coal-mine which the French are working in Tonquin. It is the Hatou, and is said to yield excellent coal (at present about 500 tons a day) by the simple method of stripping. The length of the seam is stated at 16 miles and the thickness at nearly 200 feet! The published account does not say that this immense thickness is in one solid mass, but it is left to be assumed that it does not mean the total of a series of separated coal-beds. Very naturally this remarkable deposit is described as "practically inexhaustible"—an expression often loosely used in reference to mineral deposits. According to the ratio of reduction in bulk in the formation of soft coal from vegetable matter, as usually estimated, this thickness of coal would represent about 1350 feet of fairly compact woody substance, without allowance for loss; and might furnish some astonishing figures as to the time and the extent of the original vegetable growth required to produce such a mass.

THERE are some peculiar mines. A newspaper describes what it seriously calls an aluminum-mine—meaning a promising bank of pure clay. The writer was once invited by an enterprising but innocent publishing-house, then about to issue a book on mining, to furnish some information on mines of gold, silver, iron, lead, copper, and *brass*. But there are some stone-mines. That the ancients obtained stone by true mining, Mr. Durfee has shown in his admirable paper on "Quarrying Methods of the Ancients" (in the July number of this Magazine); and at present there are a few stone-mines, where the material is of sufficient value to warrant the method.

IRON and steel props cannot be said to have fairly reached even the experimental stage in American mines. Indeed there is no occasion for experiment. The results of European experience, now quite extensive and successful, and of the few trials in the United States, show what may be expected of metallic supports. There is no question as to their great merits. It is simply a matter of relative economy. Under present conditions timber can hardly be displaced by metal except under peculiar conditions, as in exceptionally difficult work, or for permanent openings of the greatest importance, or in treeless regions where freight charges may put timber and metal on terms of greater equality. Steel "tubbing" is of course indispensable in some cases. Iron and steel ladders, head-frames, and guides are also common. No doubt in time we shall use metal props, etc., very largely, beginning with the large eastern coal-, iron-, and copper-mines. It may be added that when we do come to the use of metal in earnest, the props, stulls, caps, shaft-frames, etc., will be of steel rolled to suitable form, convenient for setting and replacing, and shaped in accordance with the stresses so as to use the material to the best advantage. Makeshifts of old rails can have but limited application, though ingenious systems of framing with them have been invented.

A RECORD for fast tunnel driving was made recently in the tunnel of the East River Gas Co. under the East river, New York. In one week the day shift made 48′ 6″ and the night shift 52′ 6″—a total of 101′. The heading is 10′ 6″ × 8′ 6″, and is advanced in full section. The rock is very hard hornblende-gneiss. This is remarkable work, considering the peculiarly difficult conditions of the locality, and is claimed to be the quickest tunnel-driving of the kind. Four 3½″ Ingersoll-Sergeant drills are used in the heading, mounted on tunnel-columns with arms; two drills on each column. About 15 holes, 9′ to 10′ deep, are drilled by each shift, consisting of five machine-runners and their helpers. Compressed air for running the drills and pumps, and also for ventilation, is supplied by an Ingersoll-Sergeant air-compressor, of the latest improved piston-inlet type, "straight line" pattern, having cylinders 20″ diameter by 24″ stroke, furnishing about 1050 cubic feet of free air per minute.

THE inspector of mines for the North Staffordshire district, England, reports that the use of "safety" or so-called flameless explosives continues to increase in that district, displacing gunpowder, those chiefly used being roburite and ammonite; trials also being made with some new brands. The water or gelatinous cartridge continues in use, with geglinite and tonite. No injury from fumes by any of these explosives has been complained of. The inspector says that the wisdom of adopting these safer explosives (with electric firing) in dusty or gaseous mines is not to be doubted.

CIVIL ENGINEERING

Conducted by John C. Trautwine, Jr.

DURING recent years the harbor of Genoa, Italy, has been thoroughly improved and enlarged by the construction of two new breakwaters, respectively 4800 and 1600 feet long, sheltering an outer harbor of 250 acres, while in the inner harbor about six miles of new quay-walls have been built and provided with sheds, hydraulic hoisting-machinery, railway sidings, and accessories. Two granite graving docks, respectively 750 and 650 feet long, have also been built, and near them a quarantine station.

The whole cost of the works has been about $15,000,000, and of these $5,000,000 were given by a Genoese nobleman, the Duke of Galliera. Of the other ten millions, eight were provided by the general government and two by the municipality.

The breakwaters are in depths of water varying from 50 to 95 feet, and are of rubble masonry. Each consists of a mound extending up to 20 feet below low-water mark, and surmounted by concrete blocks regularly laid down in steps. Upon these is built in turn a wall of masonry with its top 30 feet above mean water. Concrete blocks were used also for the subaqueous parts of the quay-walls, and are surmounted with masonry. Each of the graving docks is a monolithic structure of concrete faced with granite ashlar.

The construction of these works required 120,000 cubic yards of concrete, 440,000 cubic yards of concrete blocks, and 280,000 cubic yards of brickwork, masonry, and ashlar.

The resident engineers on the works were Chevalier Luigi Luiggi, of Genoa, and Mr. V. Cardi, of Pisa, who, taking advantage of the magnitude of the undertaking, instituted and carried out a most elaborate series of experiments on concrete and masonry. The experiments extended over a period of twelve years, and embraced a vast amount and variety of materials. Their results have been published in Italian by order of the government and adopted as a standard work for Italian maritime engineers.

Much attention was given to the properties of pozzuolana, a volcanic sand found in large quantities near Naples and Rome, which forms an excellent hydraulic mortar when mixed with ordinary lime. In Italy, where Portland cement is very costly, this mortar of ordinary lime and pozzuolana, which costs little more than sand, is very extensively used. It was employed by the ancient Romans, and there are still existing in Italy many harbor-works where it has remained in perfect condition for fifteen or twenty centuries.

Many experiments were made to determine the best proportions of cement, sand, gravel, and water for different purposes, the influence of temperature and of frost on cement mortars, the use of fresh water and sea-water for mixing, etc.

Special attention was given to the porosity and permeability of mortars,—subjects upon which but little has been written, but which are of the greatest importance in the construction of works which must remain tight under the pressure of water. The porosity of mortars depends upon the existence of voids of three kinds: first, those existing between the grains of sand or pozzuolana and not completely filled by the cement or lime; second, those due to the air which adheres to the surfaces of the grains; and third, those left by the evaporation of the water used in the mixing. These three classes of voids have been thoroughly investigated and discussed.

The conclusions arrived at are: that cement mortars are less porous than those made of hydraulic lime and sand or of ordinary lime and pozzuolana; that cement mortars made with coarse sand are less porous than those where fine sand is used; that neat cement mortars are more porous than those made with sand; and that the proportions between the voids and the apparent volume of the mortar may vary from 12 to 46 per cent. The lowest porosity, 5 per cent., was found in a concrete composed of 700 pounds of Portland cement, 1 cubic yard of mixed sand, and 1 1-4 cubic yards of small gravel.

Paradoxical as it may seem, the experiments showed that the permeability of mortars, so far from being a consequence of their porosity, is in fact almost inversely proportional to it. The exhaustive experiments made in this connection showed: that with the same proportions of cement, mortars made with fine sand are less permeable than those made with coarse sand; that, with the same quality of sand, permeability decreases as the proportion of cement increases; that mortar made with neat cement is the least permeable of all; that concrete made with 700 pounds of Portland cement, 1 cubic yard of mixed sand, and 1 1-4 cubic yards of small gravel, and molded in the shape of a hollow cylinder with a shell 2 1-2 inches thick, was impermeable under a head of water of 13 feet, while a mortar made with the same amount of cement and sand, but without gravel, and molded as above, was somewhat permeable. Under a head of water of 27 feet, the concrete was barely permeable, while the mortar of cement and sand was very easily permeated. Concrete made with 1150 pounds of Portland cement, 1 cubic yard of mixed sand and 1 1-4 cubic yards of small gravel, mixed very accurately with the amount of water strictly necessary to work it up (say 1-3 cubic yard of water), was impermeable under a head of 40 feet.

The effect of exposure to wave action, the labor required in the construction of different kinds of masonry, and the adhesion of mortar to different materials were carefully studied.

MR. L. D'AURIA has recently constructed under his patents a direct-acting, non-rotative pumping-engine using steam expansively in a simple cylinder by means of quick cut-off valves. It is claimed that the high-duty attachments already in use, while they enable steam to be employed expansively in direct-acting non-rotative pumping-engines, cannot be used in combination with a simple cylinder with any cut-off, since they can adapt themselves only to a certain variation of the propelling force of the engine. In other words, the engine must be made to suit these high-duty attachments in order to maintain satisfactory results, whereas the device employed by Mr. d'Auria adapts itself to every condition of the engine. It consists simply in fixing upon the piston-rod of the engine, a plunger working in a special cylinder whose heads communicate with each other by means of a long pipe. Both the cylinder and the pipe referred to are kept constantly and absolutely full of water by means of a simple automatic feed-device, so that at each stroke of the engine the mass of water in this cylinder and pipe must be set in motion by the plunger. This mass, in acquiring its velocity, absorbs almost all of the surplus of work done by the engine during the early part of each stroke, during which the steam-pressure line ordinarily rises considerably above the line of resistance, but the energy thus imparted to the water in the pipe is given up by it again to the plunger during the latter part of the stroke, when the steam-pressure in the cylinder is less than the resistance. By properly varying the length of the pipe, its diameter and the diameter of the plunger, any desired piston-speed can be obtained under given conditions of steam-expansion. The plunger is provided with a series of small holes in its periphery near each end, so placed that the water pressing the plunger forward during the latter part of the stroke is allowed to flow through them when at a very short distance from the entrance end of the stroke. Its pressure upon the back of the plunger is thus relieved, and all danger of striking the cylinder-head is thereby avoided, even though there may by accident be some residual energy in the liquid mass at the end of the stroke.

The engine was constructed in the shop of the Adams and Price Locomotive and

Machine Works, Nashville, Tenn. It is a duplex, simple, non-condensing engine, cutting off steam at about one-fourth of its stroke. The diameter of the steam-cylinder is 12 inches, the diameter of the pump-plunger 6 inches, and that of the plunger of the regulator 8 inches, all with a nominal stroke of 12 inches.

The regulator pipe is 4 inches in diameter and about 45 feet long, forming a U about 20 feet in length, lying horizontally under the engine. Its action prevents any jerk or sudden change of motion.

Disinterested experts who have watched the working of this, the first engine of the new type, are enthusiastic in their admiration of its results.

A valuable feature developed during the experiment is the ability of the engine to run as an air-compressor under steam-expansion with full stroke.

The object of the inventor in constructing this first engine was to test the adaptability of his regulator to any variation of the propelling force of the engine, knowing that, if good results were obtained with an engine cutting off steam in a simple cylinder at one-fourth of the stroke, still better results, if possible, must attend its application to engines with compound cylinders, because in such engines the variation of propelling force is less trying.

The regulator is self-lubricating, and no mechanism whatever is employed in its operation. It therefore requires no special attention, and the engineer in charge has no more trouble or responsibility than with an ordinary low-duty engine.

IN THE ENGINEERING MAGAZINE for June mention was made of a suggestion by Mr. M. J. Murphy, street commissioner of St. Louis, for the holding of a national convention of members of boards of public works, with a view to the interchange of ideas and of information respecting municipal government and municipal works. Nothing need be said to impress upon the observant inhabitant of any large American city the desirability of holding such a convention; and it is therefore gratifying to note that Mr. Murphy's proposition has now taken definite shape in a call for such a convention, to be held in the city of Buffalo, N. Y., during the current month. That city was chosen, we are told, "both because of its geographical location and because of the enterprise and advanced ideas of the members of its board of public works and its large area of improved and paved streets."

AMONG the interesting objects to which the attention of the eastern members and guests of the American Society of Civil Engineers was called, on their way from New York and Philadelphia to Niagara Falls to attend the annual convention there, was the big fill, 145 feet deep, by which the new line of the Lehigh Valley railroad along the east bank of Seneca lake, crosses Breakneck hollow, one of the deep and steep and rocky ravines which discharge their waters into the lake on that side. The fill is 1100 feet long, with a spread at the deepest portion of about 400 feet, and required 640,000 cubic yards of material. The stream is carried under it through a semi-circular arch culvert 20 feet in diameter. In beginning the construction of this culvert upon the original location, it was found that this had been placed in what was evidently an ancient stream-bed; for, instead of the rock that was expected in view of the outcrops just above and below the site, it was found that a bed of compact blue clay extended to a depth of nearly forty feet below the bed of the stream, as tested by sinking a 6-foot well. The axis of the culvert was thereupon shifted, parallel with itself, a distance of 125 feet, and was located upon the top of one of the two rocky cliffs which once, no doubt, formed the banks of the ancient stream. This change involved also a shifting of the alignment of the road some 250 feet up-stream. The rock, however, fails under one of the four wing-walls, and this portion was constructed upon a foundation of timber and concrete resting upon the blue clay. During the two years that have elapsed since construction, no perceptible settlement of this portion has taken place. The work was under the direction of Paul S. King, the chief engineer of the new line.

AT a recent meeting of the Western Society of Engineers, Mr. Charles V. Weston read a very interesting and instructive paper describing the construction of a tunnel designed by Mr. Samuel G. Artingstall, and carried under the Chicago river for the West Chicago street-railroad. This tunnel, which, with its approaches, is a little over 1500 feet long, passes under the river near Van Buren street. The depth of the river is about twenty feet. In order to avoid accidents to passengers, such as have occurred in the narrow tunnels of some of the earlier lines, this tunnel was given what otherwise would have been an excessive width, allowing about 5 feet clear space between the car-bodies and the wall of the tunnel, and over 4 feet between two passing car-bodies.

The portion immediately under the river was constructed in two coffer-dams, occupying respectively and successively the western and eastern channels of the river, one channel of course being always left open.

The original plans involved the underpinning of the foundations of several buildings under which the tunnel passed, but, as the contractors were given the option of removing these buildings and rebuilding them after the completion of the tunnel, they chose the latter alternative, believing it to be the cheaper and the less dangerous.

To protect the tunnel from leakage through its roof and side-walls, an asphalt mortar composed of Trinidad asphalt and gypsum was used in the outer courses of the brickwork.

NOW that the opponents of the scheme for a miscalled "boulevard," to extend from the new Broad-street station of the Pennsylvania railroad northwestwardly to the southern extremity of Fairmount Park, in Philadelphia, have secured its defeat through a veto by the mayor of the ordinance passed by city councils ordering its construction,—a veto based chiefly upon the far more urgent necessity of many other matters, prominent among which was a radical improvement of the water-supply,—the Philadelphians are beginning to look for signs of action leading to the introduction of these more urgent improvements. The Citizens' Municipal Association's Committee on water-supply and sanitation, at a recent meeting, ordered that a communication be transmitted to councils, endorsing the plan of water-supply extension proposed by Director Windrim, of the department of public works, which plan had already received the approval of the mayor. This plan involves the impounding of the waters of the Perkiomen and Tohickon creeks, affluents of the Schuylkill and Delaware rivers respectively, and the construction of an aqueduct about twenty-eight miles long, to conduct those waters to existing reservoirs within the city limits,—notably the East Park reservoir, which is much the largest and one of the most recently constructed of the city reservoirs, and the large high-level Queen Lane reservoir, now nearing completion. The cost of the work is estimated at about $9,000,000 and councils are asked for an immediate appropriation of $4,000,000, in order that a portion of the work may immediately be put under contract.

The supply here contemplated will be supplementary to that now derived from the Schuylkill river, and it is argued that the diversion of the Perkiomen into the aqueduct need not materially diminish the available flow of the Schuylkill, inasmuch as the storage reservoir will be supplied chiefly by the storm-water flow, most of which might be expected to flow past the city's pumps, unutilized in any case. The impounding of the waters of the Perkiomen was proposed by Chief Engineer H. P. M. Birkinbine as far back as 1865, and the project has been periodically before the public ever since. It has of course received careful study, and a measure of approval, from the various boards of experts who have from time to time investigated the subject of the city's water-supply. A powerful argument in favor of this plan is the claim that it may, when occasion and opportunity arise, be made the nucleus of a more far-reaching scheme by which water may be taken from the upper Lehigh and Delaware rivers, which, no doubt, will ultimately be required. In the meantime, the city is endeavoring to keep pace with the growing demands of the population by increasing its pumpage capacity. To this end, two new vertical triple-expansion pumps, to raise 30,000,000 gallons daily each, are now being erected at the Spring Garden works. These are the largest works in the city's plant, containing nine pumps which embrace a very wide variety of design, and which lift in all about 150,000,000 gallons daily, or more than all the other works combined. The two new pumps will be the largest in the city service.

The objection urged against the Perkiomen plan at the citizens' meeting by a gentleman who is very familiar with the stream, that in dry weather its visible flow is practically *nil*, is met by the fact that, with its water-shed of more than 200 square miles and an annual rainfall of over forty inches, it must furnish a very considerable available supply, whether that supply be visible or not, and that a dam, sunk to a proper depth, will bring the major part of that supply into its reservoir. It is estimated that the Perkiomen and Tohickon together will furnish more than 200,000,000 gallons daily, or a little more than the present pumpage. The fact that this enormous quantity is consumed, or in some way or ways disposed of, by a population of say 1,200,000, indicates that there is a fine opening in Philadelphia for the meter-man. Whether a reliable meter exists or not, the fact that the water one uses and wastes passes through a machine which adds to his bill every spoonful consumed, must certainly tend to the prevention of waste. If it had no other result than to stop the indiscriminate washing of sidewalks and marble facings, by which the Philadelphia housewife has excited the risibles of the whole country, it might be well worth the cost, as a mere matter of personal convenience.

In this Department of the Magazine for August, considerable space was devoted to a study of the reports of the city engineer and the water-works department of the city of Boston, and we are now in receipt of the report of a joint board appointed by the legislature and composed of the board of metropolitan park commissioners and the now justly famous Massachusetts state board of health. The duty of this board was to "investigate the sanitary condition and prepare plans for the improvement of the beds, shores, and waters of the Charles river, between Charles-river bridge and the Waltham line on Charles river, and for the removal of any nuisances therefrom." Mr. F. P. Stearns was appointed engineer of the board, and its report embraces one from that gentleman. The board finds that the increase of pollution of the river has driven away the better class of dwellings which formerly lined its banks, and has caused them to be replaced by manufacturing establishments and by the dwellings of those who are not in a position to be over-scrupulous about the character of their surroundings. Even in its lower reaches, where it passes through the fashionable Back Bay district and where its waters receive the purifying effects of great volumes of salt-water brought in by the flood-tide,—"even here the river has ceased to be a welcome neighbor, except so far as the views of the distant hills to the north and west are enhanced by the water in the not too near foreground, a foreground consisting of a poorly-kept alley-way behind a line of unsightly sheds and stables situated at the rear of the lots on the north side of Beacon street; a rude stone wall, upon which grow tufts of seaweed and unsightly grasses, holding, as sponges do, the floating putrescible materials that come in contact with them; and, at the base of the wall, at low tide, a muddy expanse of many acres, marred by rubbish of every description."

It has been generally believed that the steady increase of malaria in the Charles valley was closely related to the increase in the pollution of the stream, but a careful sanitary survey of the district by Dr. Robert W. Greenleaf fails to show clearly the existence of any such relation. The cases of malarial fever discovered in the district were satisfactorily accounted for by the existence of local conditions independent of the state of the river, or by the exposure of the victims to malarial influences in other regions.

The board believes that the dredging of the exposed flats and the continuation throughout the entire stretch of a substantial and handsome embankment like that constructed by the city at Charlesbank would be too expensive a remedy and that the rising and falling of the tide would soon cover the walls with offensive growths such as already disfigure those at Charlesbank. The board therefore recommends rather the construction of a dam near the lower end of the stretch in question, and the maintenance of the level, in the basin thus formed, at a nearly constant elevation about seven-and-a-half feet above ordinary low tide, or two-and-a-half feet below ordinary high tide. This will permit the utilization of the sea-water to counteract the fouling of the fresh-water stream, and will at the same time give ample opportunity of wasting any excess of stream-flow at low tide. The dam is to be provided with a lock, of sufficient size to pass the largest vessels that navigate the river, but for small boats it is proposed to provide a run-way, like those used at the weirs on the Thames, or some other convenient means of passing the dam. The dam is designed with a width of 100 feet, and will thus provide a foundation for another roadway between Boston and East Cambridge. The cost of the dam is estimated by Mr. Stearns at $660,000, and the basin formed by it will contain 3,300,000,000 gallons of water, which will be replaced, with the average flow of the river, once in fifteen days, and, with the minimum and maximum flows, in eighty-two days and in one week respectively. The area drained by the river above the proposed dam supports a population of 321,000.

It has been persistently urged that the damming of the streams entering the harbor must exert upon the currents in the harbor an effect prejudicial to the harbor itself, and this view is sustained by the report of a board appointed in 1859 by the United States government at the request of the Boston city government. This board reported that the upper harbor of Boston could not, in its opinion, afford to lose another cubic yard of tide-water. The present board, nevertheless, holds that the construction of the proposed dam cannot possibly exert any unfavorable effects upon the harbor. The Boston report is embellished with a number of handsome photographic views showing the beautiful character of that portion of the city of Hamburg which surrounds the Alster basins, as indicating what might be expected to follow upon the creation of similar basins upon the Charles.

TRULY a remarkable state of things must have existed at the mining town of Ironwood, Mich., according to a paper presented by Mr. E. A. Rudiger at a recent meeting of the Western Society of Engineers. An investigation, following an outbreak of typhoid fever in the town, developed the fact that carcasses of dead animals had been deposited upon the banks of a small stream, which, after draining a portion of the town, discharged into the river a short distance above the intake of the water-works. The startling feature of the matter is the fact that the carcasses were so placed by order of a member of the board of aldermen and committee on health, and it was perhaps but just retribution that this public guardian himself died of the fever.

THE North-river bridge project has been meeting with opposition at the hands of the chamber of commerce of New York. This body objects to that feature of the design which places the piers beyond the pier-lines on both sides of the river, arguing that the presence of the piers would be in the way of large tows and would interfere with the passage of ice in winter. The chamber proposes a bridge of 3200 feet clear span and 500 feet clear height, and submits a letter from Engineer Roebling endorsing its practicability.

MECHANICAL ENGINEERING

Conducted by Henry Harrison Suplee.

THE present complication between China and Japan is being watched with more than usual interest by civilized nations, and especially by the members of the engineering profession, because it bids fair to furnish a practical demonstration of the real merits of the appliances of modern warfare. Both China and Japan are equipped with vessels, guns, and weapons of all sorts from the leading makers of Europe, and Japan at least has men well trained in Europe and America in the use of all these engines of war. At the same time, most of these expensive pieces of fighting machinery cannot be said to be far beyond the experimental stage, and indeed many of them, so far as operation is concerned, exist merely on paper. Of course it is not the fault of the inventor that a new military appliance does not receive an immediate test in actual warfare, when no two nations are accommodating enough to give him a convenient war to exploit his latest killing device; but now that two so-called barbarous peoples have been so good as to invest millions in purchasing these things and are proceeding to put them to actual use, the scientific world is agog to see how the things will really work.

The writer remembers, as one of the lasting incidents in the once popular children's tale of the "Swiss Family Robinson," the fact that the thoughtful father kept a monkey upon which he tried every new plant found in the wonderful island upon which the family had been cast away. If the monkey was not poisoned by the experimental test the article was presumed to be safe for the rest of the family to eat. The monkey thus served as the object of many interesting experiments in the properties of plants, but sometimes it was rather hard on the monkey. In the present crisis the belligerent nations appear to be willing to play the part of "monkey" for the rest of the world, and it might be in order for the rest of the "civilized" world to wait the result for awhile and see how the new weapons work. The only objection which may be urged against such a course is the possibility that the makers of the weapons may themselves be drawn into the fight, when, of course, it would never do for them to find themselves less expert with the tools of their own inventing than the experienced customers to whom they have sold them.

THE very successful speed trial of the new triple-screw cruiser *Minneapolis* was briefly referred to in these columns last month, and the result is one in which the navy department and the nation may well feel a pardonable degree of pride. Of course the usual amount of discussion about the well-worn subject of speed premiums is now in order and, indeed, the daily press has already again settled the matter to its own proprietary satisfaction. As a matter of fact, however, the whole question of speeds is practically a comparative one, and as usual, when there is serious difference of opinion upon a subject, the comparisons are not always made upon the same basis. We have heard much about the *Columbia* being able to catch the *Paris*, or overhaul the *Lucania*, and, doubtless, if either steamer should be accommodating enough to give the crack cruiser a chance to try speeds the triple screws might show greater fleetness than the twin propellers of the ocean liner. It must not be forgotten, however, that the four hours' run upon which the record of the cruiser is made is accompanied with all the advantages which belong to a trial in the hands of the builders, and all that picked coal, clean bottom, reduced top-hamper, and general high-pressure on all individuals to "push things" can do. Just what the crack liners would do under such favorable conditions no man knows, but until the cruiser has equalled the record of the merchantman in crossing the Atlantic at top speed, with commercial coal, with engines running twenty-four hours a day for six consecutive days, and with the every-day firing which accompanies commercial service,—not until then will it be in order to say whether the cruiser would catch the merchantman, or the merchantman show her stern for a brief period to the record-breaking man-of-war!

THE method adopted by the steamship companies for testing their vessels is one which, while perhaps rather more trying to the builders, appears likely to give results of more permanent value to the owners of the vessel. An ocean liner often remains in the hands of the builders until she has made several trips across the Atlantic, and it is only after everything has been demonstrated to be in first-class order, and all speed requirements fully met under ordinary operative conditions, that the ship is finally accepted and turned over to her owners. While of course it is not to be expected that the builders of a war-ship should stand the expense of a cruise, just to see whether or not everything is all right, yet it does seem as if the large sums paid out as premiums would be better expended if used in paying for a trial cruise of moderate length, during which time the vessel should still be "in the hands of the builders" while under critical inspection of government engineers. A speed made under such conditions, while perhaps not so great as that made under the present "spurt" system, would be one which the government could reasonably expect to be repeated whenever occasion should demand, while it is not too much to say that no one has the slightest idea that the record speed will ever again be made in actual service. When an ocean liner already holds the record she usually makes efforts to break her own record, but if this sort of an attempt has ever been made by any of our crack cruisers we have yet to hear of it.

COMMENT was made in these columns several months ago, in discussing some points connected with the work of the bank and vault commission of the government, that the use of electric power by burglars might radically change the methods of attack, and the propriety of investigating this matter was suggested. It now appears that the work of the commission is to be supplemented by practical investigation of this matter, and the result will be awaited with interest. If electric power can be successfully applied for such purposes of destruction it may also be utilized for far more laudable service. It has long been held by the writer that, if all the money which has been spent in sporadic and disconnected Arctic explorations, for instance, had been applied to continuous and progressive gradual advances, each station being made permanent and serving as a base for the next season's progress, we should have wrested the secret of the pole from its ice-walled fortress long ago. An exploring party tied to headquarters, so to speak, by a string over which light, heat, and power could be sent on, could make most substantial advances, and could scarcely come to permanent grief if in constant communication with its base of supplies. In like manner not only Arctic explorations but all sorts of attacks upon nature can be vastly aided by the application of either stored or transmitted power, and the whole subject of the exploration of the yet almost unknown portions of the world assumes a new aspect. In Lord Lytton's fanciful romance, "The Coming Race," the tremendous progress of the people there described is said to be mainly due to the possession of a mysterious and portable form of stored energy which he named "vril," but it may be that its possession will be found merely in the application of means already within our hands, and the consequences of which at the present time can only be left to the imagination.

THE utilization of natural forces as sources of motive power has been much discussed and is constantly attracting more and more attention. Niagara is already passing into engineering history, and now the project for controlling the power of the tremendous northern current which sweeps down through the Irish channel is being seriously considered, the principal engineering feature in the plan consisting in the artificial contraction of the channel at the Mull of Cantyre, in order to obtain the necessary velocity. The whole question of the utilization of natural forces depends mainly upon the completeness of the solution of methods of long-distance transmission, and, these once perfected and losses reduced within practical limits, the rest will readily and promptly follow. Winds, tides, ocean currents, natural sources of heat, or differences of temperature even between widely-separated points,—all these and many others contain potentialities as yet scarcely appearing in the dreams of man, but they may be no further from realization than was the telegraph a hundred years ago, the telephone twenty years ago, or the flying machine—to-morrow?

THE subject of dimensioning drawings, concerning which we made some remarks several months ago, is being discussed to some extent in another direction, namely, as to the extent to which inches should be used before changing the notation to feet. There is no fixed practice in this respect, some drawing-offices expressing all dimensions in inches up to 36 inches, and then in feet and inches; others going as high as 48 inches; and still others no higher than 24 inches. There are various arguments for all these practices, but the best argument is that which best stands the test of daily use, and it certainly seems desirable to avoid the use of more than one unit whenever possible, unless loss of clearness is likely to result. In many cases the inch is used as a unit for still larger dimensions. In speaking of bicycle-wheels, for instance, no one would think of referring to a 54-inch wheel as 4 feet 6 inches in diameter, while with pulleys also the inch is used as far as conveniently practicable.

The metric system has yielded to this desire for simplicity to a large extent, and drawings made in that system are constantly seen with even large dimensions expressed in millimeters only, notwithstanding the provision of the centimeter and decimeter for the decimal multiples. The ease with which the introduction of the decimal point renders the transformation of units possible in the metric system of course makes this a very simple matter of choice, but, at the same time, there is much less liability to error by avoiding the use of two units, and the difference betweeen 4′ 2″ and 42″ is not so great but that errors are apt to occur when the figures are hastily made and as hastily read. It is certainly unwise to base any practice upon either the yard or the 2-foot rule, as the yard never had any place in the machine-shop or drawing-room, and the 2-foot rule is a carpenter's tool, and, in these days of accurate shop-work, is now nearly or altogether superseded by the steel scale, the micrometer caliper, or the more accurate gages of modern practice. Uniformity in practice is certainly desirable, but at least let the inch be used as high as four feet. In the writer's opinion 72 inches is to be preferred to 6 feet and can be written in less space than the latter, when the notation "ft." is used, as indeed it always should be, if immunity from errors of confusion is to be insured.

MENTION has been made in these columns already more than once of the value of graphical methods of solving both mathematical and mechanical problems, but the subject is one which will bear constant attention, and no apology is needed for frequent discussions. It is not uncommon to hear men say that graphical diagrams will do very well for approximate results, but that the superior accuracy of calculations gives them marked superiority. It is doubtless true that results can be obtained by analytical methods to a far greater degree of refinement than is possible by the use of scale and dividers, but the sense of accuracy which is pleased with results carried out to the sixth decimal place is sometimes marred by the discovery that some important element in the calculation has been omitted, or, as is often the case, that it is impossible to use the results thus laboriously obtained to a greater degree of precision than, say the second decimal place, and that the work which has been expended is unavailable.

As a matter of fact the graphical processes will give results which are nearly always as precise as any of the subsequent uses which are to be made of the values thus obtained, and it is of little use, for instance, to determine dimensions which, when obtained, are to be laid out on a drawing, to a closer value than can be read from a scale or marked with a pencil, so that for such purposes the same system is equally reliable for the one or for the other. At the same time, it is possible to use graphical methods to investigate subjects which are only solvable analytically by most tedious labor and that too by those who have kept themselves expert in this branch of work by close study and constant practice. The true end of mechanical engineering is the production of the completed and operative machine, and this itself is a drawing, executed in steel and iron, and the symbols which are but as a means to this end need never be more precise than their final outcome in any case.

AMONG the graphical methods which may be found most useful, apart from the well-known statical problems, may be cited the use of curves for the determination of a large number of values, for tabulating or transforming, for instance. By calculating a limited number of values and erecting these as ordinates a curve may be drawn from which all the intermediate values may be measured in a few moments and with an accuracy which is limited only by the scale of the diagram and the skill of the operator. In like manner many equations may be solved graphically by drawing the curve which includes the given conditions and obtaining the roots directly by measurement, when, if still greater precision is required, the substitution of these values will enable a first analytical approximation to be obtained with an ample degree of precision. A little experience will often suggest the best method to apply in any particular instance, and the growing increase in the use of such methods is ample evidence of the appreciation which is being given them by practical engineers.

AMONG the various branches of applied mechanism, the subject of lock-construction is one which has scarcely had the attention which its importance demands in technical literature. A fine lock is a piece of mechanism which requires for its construction not only the exercise of the highest degree of ingenuity, but also demands the best mechanical skill available in the domain of mechanical engineering. Nearly every other article of machine-construction is made for use only,—although of course everything has also to bear its share of abuse,—but a lock is made for the very purpose of standing ill treatment and is really only fully doing its work when it is resisting the efforts of some one to injure or force it.

As Reuleaux has well remarked of this branch of mechanism, "locks, in spite of their universal use and of the high order of inventive talent devoted to them, have had no analytical treatment, but have been relegated to the domain of technology rather by accident than otherwise." They undoubtedly belong where he has properly placed them, among the higher classes of ratchet-gearing, the combinations often reaching the second and third order even in ordinary locks, while the elaborate dial-locks, timelocks, and automatic devices reach into much higher orders of mechanism.

Probably one reason why this branch has received so little technical attention lies in the fact that, like watchmaking, the art of locksmithing was for a long time in the hands of isolated artisans, each adhering to his own traditions and holding aloof from his fellows. As this state of things passed away, the same close control of the subject continued with the larger manufacturers until the present time finds it undergoing the transformation into a product of the same scientific application of mechanical principles which has already controlled nearly every other branch of mechanical manufacture. To-day a lock is designed with the same care and with the same fullness of detailed drawings as is a lathe or a steam-engine, and the strength of its parts proportioned not only to meet the operative forces but also the destructive efforts of the enemy. The mathematical principles of permutation and combination are carefully applied in order to obtain, with the greatest simplicity, the greatest number of key changes, while the theory and practice of masterkeying presents some of the most beautiful problems which the science of mechanism has to offer. Some day this branch of mechanism will demand a treatise worthy of its importance and the information at present contained in trade catalogues, note-books, and human memory will be placed upon record in a manner comparable with that of other and no more important mechanical subjects.

MR. ECKLEY B. COXE, in his admirable presidential address at the Montreal meeting of the American Society of Mechanical Engineers, brought out a point in engineering education which has been too often overlooked. In the demand to-day for specialists, the importance of a broad fundamental training is too often overlooked, and, in consequence, a specialist often finds that some unforeseen change in practice, brought about perhaps by some new invention or method, renders his special knowledge nearly valueless, from a commercial point of view. When, however, an engineer really possesses, in the sense of *owning*, a knowledge of the fundamental principles upon which every branch of his profession is based, he may devote himself to the practice of any special portion of its wide field without feeling himself at the mercy of any sudden change in practice or method. There is an anecdote told of a schoolboy who, when asked if he knew Greek and Latin, answered that he could hardly say that he *knew* them, but could say that he was *aware* of them. It is more than likely that many specialists in engineering are scarcely more than aware of the practice of any but their own limited branch of the profession, and it is such specialists who are first to feel the force of sudden changes and upheavals.

A USE of high-pressure water, primarily introduced for purposes of motive power only, has been found in some of the cities in England where this system has been introduced, which was hardly considered in its full value at first. By using a jet of high-pressure water from the power mains as an induction jet in an ejector pump, a powerful stream for fire-extinction is available almost anywhere where connections can be made. Double-injector hydrants connecting the high-pressure supply with the main water-pipe supply, have been furnished both in Manchester and in Hull, as well as in London, and in many cases have rendered good service with but moderate use of the high-pressure water. This system is decidedly more practical than that which has been discussed in the United States, namely, that of providing sufficient moderately high-pressure water supply for direct use; and the entire subject of fire-protection by some more scientific method than the present medieval system of horses, men, dogs, and general pandemonium, in order to get a machine of limited capacity and still more limited efficiency somewhere in the neighborhood of the fire, is a consummation which is most devoutly to be wished.

COMMENT & CRITICISM

The Situation in Peru.

IN the Magazine for July I was both surprised and pained to see a communication signed "N. J. S." on the subject, why is not Peru entered and developed by Americans? Your correspondent declares that "Catholicism is the answer," and then he insinuates that Catholicism is not Christianity.

I presume that if your correspondent is an engineer he will admit that it is the business of an engineer to deal with hard, cold facts, and not with theories born of prejudice; and to draw conclusions from a long series of observations taken from different points of view, and not pass snap judgment on such a question from observations to be made in "less than an hour" in the city of Lima. Again, let a man approach the natives of Lima or any other city with the feeling that they are socially, politically, and morally beneath him, that they are a deluded, priest-ridden community, and it is no wonder that they fail to appreciate him or bow down to his superior intelligence and make him a bosom friend.

The fact is that Lima is a well-laid-out city, having the oldest university in America, together with numerous schools, charitable institutions, and a public library. In a population of about 200,000 there are seventy churches,—certainly not a very priest-ridden showing. The high price of labor has hitherto prevented any efforts at manufacturing on a large scale being permanently successful. Chinese coolies are imported under contract for all railroad construction and other heavy work. Of course Lima is not New York or Boston, and a stranger speaking a foreign tongue naturally has an up-hill time of it in getting along with the natives. The country is just recovering from the effects of the war with Chile, and this, together with the general instability of the government in South American republics, causes outside capital to be very slow in making investments. The fact that among other public works the railway was constructed over the Andes with its numerous switchbacks, tunnels, and bridges, on one of the most elevated and most difficult locations in the world, would indicate that spectacular religion is not the principal business of the country, as your correspondent would have us believe. Also the fact that at the port of Callao over 2000 vessels arrive and depart annually, doing an annual business of over $30,000,000, would seem to point the same way.

An author who evidently took in the whole situation gives his conclusions as follows:

> We have no reason to believe that more than one acre in a hundred of maritime Peru will ever be available for the sustenance of mankind. The country has two advantages—its mines of the precious metals and a temperate and delightful climate. It can never be rich in the proper sense of the term, or make much progress in the improvements which depend upon a dense population. It has no navigable rivers, and nature has deprived it of the means of forming good roads. There are indeed few countries in the world whose natural advantages have been so much overrated as Peru; and it requires little sagacity to discover that its future career cannot correspond with its past celebrity. The districts east of the Andes, which have a hot climate accompanied with a rich soil, will ultimately be the most valuable part of the country.

While we all admit that this Yankee nation of ours contains the greatest "hustlers" in the world, yet, since we have copied the Australian ballot and the Swiss referendum and the Norwegian liquor-law, we may possibly discover something worthy of imitation in Peru, where they are not given up wholly to the worship of the almighty dollar, and where the worship of God is the rule rather than the exception, which we fear is the tendency in our own country.

J. T. D.

No Obstacle in Peru.

UNDER the caption "The Obstacle in Peru," there appeared in this department of the July ENGINEERING MAGAZINE such an unjust arraignment of the relation existing between the church of Peru and the civil life of the republic that I must claim in the name of truth a little space to set the matter right. Certainly the church of Peru contains little to excite the devotion or respect of intelligent men or women. It is tyrannical to the poor and humble, craven to the rich and powerful, and altogether a rotten mass of depravity. Its clergy are, with rare exceptions, drunken debauchees; its religious orders are also grossly immoral,—notoriously and publicly so. But nothing in all this horrible condition militates against the Protestant foreigner. So far is it from being true that "Religion is the supreme concern, and all business affairs are mere side-shows that get along the best way they can," the church has an exceedingly lax hold on any but the very ignorant. Even religious processions are prohibited on the streets of the capital, and the "feast days" of the church are simply excuses among all classes for frolicking and drunkenness. This vice and not the church keeps the carpenter from his work on Monday and interferes with the continuity of labor. But this result is the fault of the employer of labor as well as of his journeyman.

I have lived eight years in Peru, in constant charge of public works, and have at times had 1700 men employed, Peruvians and Chileans, all Catholics of the Spanish church. Even my immediate assistants have been of the same faith, and yet I have never experienced the difficulty your correspondent complains of. Indeed, the South Americans as a rule are less devoted to their church than were the Irish navvies of forty years ago in these United States. The educated men of Peru are agnostics, as are all the class in Spanish America. The church is a civil institution of the country, of which the officers, its clergy, are, like many other politicians, corrupt leeches fattening on the public blood. They are rarely admitted to good society, being generally recognized as unfit associates for the families of self-respecting husbands and fathers; but the ceremonies of the church invest with a certain dignity the bestowing of names on children, the solemnizing of marriage, and the final burial of the dead.

Beyond these affairs, not one man in a hundred ever troubles the church on other than patriotic occasions, when a mass of *gloria* or *requiem* is to be celebrated.

Americans and Englishmen are doing as well in Peru as they deserve to. They are admitted to as good society as they are allowed to enter at home. But, unhappily, the country has been visited by a multitude of American adventurers, whose ability in poker and whiskey obscures any other virtue they may happen to possess.

ALFRED F. SEARS.

New York, August 4, 1894.

A Correction and a Protest.

THE article of Mr. H. Guillaume, "Business Opportunities in Peru," in your June issue, conveys a mistaken impression as to the extension of the Central railroad. The distances and heights of the principal stations are as follows:

Dist. in miles.	Stations.	Heights in feet.
0.0	Callao	8.7
7 7	Lima	500.0
33.2	Chosica	2,800.6
47.1	San Bartolomé	4.959 4
63 6	Matucana	7,788.8
78.5	San Mateo	10,534 1
87.2	Chicla	12,215.5
106.1	Galera tunnel	15,665.2
136 5	Oroya	12,178 7

I cannot close these remarks without a protest against the article "The Obstacle in Peru," in the July number, by N. J. S., of Frankfort, Ky. Your correspondent was probably "plumped down in a balloon in Lima," and plumped up again, without time to form an opinion. I would appeal to the testimony of such persons as Messrs. Virgil P. Vogue, O. F. Nichols, Leffert L. Buck, Maxwell, and many, many others who have lived and worked in Peru for years, and who would be utterly surprised at the fancy picture drawn by N. J. S. (probably from stories of the Peru of Pizarro of the sixteenth century).

E. C. ZEGARRA, C. E.

Piura, Peru, S. A., July, 1894.

[NOTE.—In view of the opposition which

the communication referred to has aroused, it becomes proper to say that N. J. S. is a professional gentlemen of the highest standing, well known to us, who spent several years in South America, and has since kept in touch with Peruvian and Chilean affairs through friends and acquaintances there, among them Americans closely identified with the business interests of Peru.—THE EDITOR.]

Photography of Working Drawings.

ON page 590 of the Magazine for July appears a note in regard to the reduction of working drawings by photography. I have found this method very convenient and have carried it still further by having a retracing made from the reduced print. On this are placed the figures and other data in such size as to be conveniently read, and prints from these in most cases, can serve all the uses of the larger blueprints. By judicious choice of scales, the essential points of several drawings can be incorporated in one 8′ × 10″ print, which is readily enclosed in an ordinary business envelop, yet contains sufficient matter for the assembly of machines, lay-out of foundations, or general information. The expense of the reduction is small, as the draughtsman can trace without lay-out everything except title and figures, and the fact that I am supplying several hundred of them per month in place of larger drawings is sufficient evidence of their practical value. F. G. PRATT.

Schenectady, N. Y., July 16, 1894.

Weight of Sand and Cement.

IN an article on cement and cement-testing in the Magazine for June, the weight of sand is said to be less than of cement of equal quantity by measure. By actual trial at the laboratory here we find the weight of a cubic foot of loose cement:

Pizzolau	57.4	Portland Cements.
Sphinx	73.2	
Dyckerhoff	76.5	
Alseus	68.0	
Average	68.8	

As an average of a number of experiments we find when sand and cement are taken loose as in laboratory testing, cement weighs 65 per cent. of weight of equal quantity of sand by measure. That is, 5 of sand to 1 of cement by weight is equivalent to 3.25 of sand to 1 of cement by measure, and 3 of sand to 1 of cement by weight is practically 2 to 1 by measure.

JAMES D. M'KEE.

Waterworks Extension, St. Louis, Mo., June 2, 1894.

CURRENT TECHNICAL LITERATURE

The Practical Management of Dynamos and Motors. By Francis B. Crocker, Professor of Electrical Engineering, Columbia College, and Schuyler S. Wheeler, D. Sc., Electrical Expert of the Board of Electrical Control, New York City. With a special chapter by Horatio A. Foster. Second Edition, revised and enlarged. New York: D. Van Nostrand Co. [Cloth. 8vo. 205 p. $1.]

THE contents of the first edition of this book appeared first as a serial in the *Electrical Engineer* during 1891–92, its object being to give simple directions for the practical use and management of dynamos and motors. In the preface to that edition the authors stated that it was the design that the book should be simply the groundwork of a larger and more elaborate treatment of the same subject. How well this first edition met an already-created want was evidenced by its exhaustion in less than a year, and the present volume is the fulfilment of the promise then made. In this we find many additions which have largely increased the value of an already-valuable work. The chief of these are in the chapter on examination and testing of machines and the special instructions for handling the Thomson-Houston, Brush, and other arc-light machines.

The first of these additions has made the chapter on examination and testing so full as to entitle it to a department by itself and it now appears as Part II. The latter additions, which cover a class of machines not treated in the first edition, constitute Part IV.

This work is an eminently practical one on an eminently practical subject, and, as it is intended more especially for those who are not versed in electro-technics, has been couched in simple terms which all may understand.

Messrs. Crocker and Wheeler, aside from their responsible professional work, are also engaged in the extensive manufacture of motors, but they are regarded by the profession no less highly for their scientific achievements than for their work in the more practical line of manufacture into which they have brought to bear in a most practical way the teachings of advanced science. They therefore speak with an authority upon all subjects of which they write, which is recognized by every one, and their book would need no better introduction to the public than the weight of their own names. It has, however, had the further introduction of a first edition which has given it a prestige that even their personal reputations could not give.

Mr. Horatio A. Foster, who adds the chapter on the Thomson-Houston arc-dynamo, is also specially qualified to write on his subject. Mr. Foster, while connected with the Thomson-Houston Co., devoted his time exclusively to the study of the diseases and remedies of this peculiar though well-known machine, so that he is to-day probably the best authority on its management in this country.

With such sponsors it is not a surprise that the book is what it is, viz., by long odds the best that has thus far been published on the practical management of dynamos and motors. Part I is strictly elementary in character and deals with general principles at first, followed by chapters giving instructions on selecting dynamos and motors, circuits and windings, installing and belting machines, wiring and connections, and starting dynamos. Chapter VII is an extremely practical one, dealing with the various ways of switching dynamos of the different kinds into circuit. This chapter is fully illustrated with cuts which assist the text so that the reader cannot fail to understand the instructions given.

Not only are the direct-current machines —short,series,and compound—here treated, but also alternating-current machines. Chapter VIII is devoted to a description of the different types of motors and the precautions necessary in starting the same. Chapter IX gives general directions for running dynamos and motors and as to personal safety and chapter X, which closes Part I, is devoted to precautions to be observed in stopping the machines.

Part II, which is devoted to "examination, measurement, and testing," gives in seven short chapters full instructions suitable for the dynamo-tender as to what to measure and how to measure it, together with brief descriptions of the instruments needed, with diagrams showing the proper connections when in use. This is the least satisfactory part of the book and necessarily so on account of the utter impossibility of compressing within 34 pages a treatise on electrical testing. The subject is admirably handled, however, considering the limitations in space which the authors have imposed upon themselves, but we would like to see in the next edition more space given to this subject.

Part III, on the localization and remedy of troubles in dynamos and motors, will undoubtedly be more widely appreciated than any other, as it appeals directly to those who are in trouble and who, when perplexed as to the cause of a difficulty, have no one to go to to ask instructions, or who must act immediately. It is not intended that these instructions, which are sometimes somewhat empirical, shall supplant, but rather that they shall supplement, a more intimate knowledge of dynamo-electric machinery. They are written, however, more particularly for the layman, but serve nevertheless as a ready reference for those better posted. The style is therefore that of the household medical book rather than that of the medical treatise. For instance, under "sparking at the commutator" we find fourteen separate causes—marked 1 cause, 2 cause, 3 cause, etc. Under each *cause* comes *symptom*, with a description by which the cause may be recognized, and this is followed by *remedy*, which gives simple instructions how the difficulty may be rectified.

There are eleven chapters in Part III, each of which is devoted to a different class of troubles, such as the one just referred to, heating of armature, motor stops or fails to start, dynamo fails to generate etc.

Part IV is devoted to dynamos and motors reqiring special directions and comprises: Chapter XXIX, Thomson-Houston arc-dynamo—setting up; Chapter XXX, the same—troubles and remedies; Chapter XXXI, Brush arc-dynamo; Chapter XXXII, Fort Wayne, Sperry and Excelsior arc-dynamos; and Chapter XXXIII, arc-motors.

It will thus be seen that the scope indicated by the title is quite fully carried out in the text, and, it may be further said, most admirably carried out. It has seldom been our pleasure to give a book the unqualified endorsement that we can and do give this one, and we heartily wish that this little brochure could be placed in every dynamo-tender's and motorman's hands, both on account of the assistance it would be to them and on account of the saving it would effect in wear and tear to the machinery through the increased intelligence with which it would be handled.

NELSON W. PERRY.

Les Travaux Publics et les Mines dans les Traditions et les Superstitions de tous les Pays. By Paul Sébillot, Ancien Chef du Cabinet, du Personnel et du Secrétariat au Ministère des Travaux Publics. Paris: J. Rothschild.

In these depressing days, when work for the engineer is at a premium, a work dealing, as this does, with the romantic side of engineering may well find acceptance. The author lays before his readers a wealth of information and of illustration arguing a vast deal of patient and painstaking labor, and forming, together, a volume of exceptional interest.

Devoting his first chapter to common roads, in treating of which he reproduces some excellent old prints of ancient Roman highways, the author passes on to the subject about which tradition and superstition seem to have chiefly exercised themselves: that of bridges. One is tempted to believe that St. Peter could hardly have had more churches than the devil has had bridges. It is curious how little originality is sometimes displayed by the framers of tradition. The old story in which the devil comes to the assistance of the engineer distracted by the difficulties of the location of his bridge, offers his assistance, generally on condition of having for his own the first person who crosses the bridge, and then, like a gentleman, carries out his part of the contract by seeing the engineer through and the bridge completed, while the engineer, with an impudence that ought to shame the other party to the contract, puts him off with a dog or a cat,—this story seems to have done service in connection with each one of the innumerable "devil's bridges" scattered over Europe, the despair of the traveler desirous of visiting the veritable devil's bridge.

In this chapter the author shows excellent sketches of the Pont de Veille-Brioude, the Pont de Ceret, and the Ponts du Diable, in Catalonia, over the Reuss, and at Lanza, but seems to have overlooked the great bridge which once spanned the Adda at Trezzo, in Italy, with its single arch, said to have had a span of some 250 feet, the remains of which are still standing.

As a matter of recent history, though it may not have been a case of superstition, the author mentions that at the laying of the corner-stone of the bridge over the Seine at Conflans, in 1890, in presence of M. Yves Guyot, minister of public works, it was discovered at the last moment that none of the assistants had about him a coin bearing the date of that year, and some delay was submitted to while search was made in the neighborhood for the desired article.

A practical point for the pile-driver is the belief attributed to the Japanese, that, if a pile be placed with its narrow end downward, the sprites inhabiting it, resenting the inversion, will take flight and the pile will at once decay.

If the steam railroad had been a growth of the middle ages, it would no doubt have given rise to a scheme of tradition and superstition, compared with which those that cluster about the bridge might hide their diminished heads. As it is, that comparatively modern invention forms the subject rather for caricature.

Under canals and lakes, as well as under mines, the divining rod, as might be expected in a work of this sort, plays a prominent part, and a number of excellent old cuts are reproduced, showing various methods of holding this uncanny instrument.

Our author, however, does not confine himself to the romance of engineering. Under the head of "harbors" is shown an interesting cut illustrating an ancient method of dredging. A grapple is placed in the stream, a little way out from shore, and connected with the shore by a rope, a few turns of which are taken around an upright pole which is stayed at the top by guys. The workmen then, turning the pole by means of horizontal levers, drag the grapple in toward shore, the grapple bringing with it the dredged material.

Under "mines," also, is shown an old cut from de Bry's "Voyages," illustrating the interior of a mine at Potosi, and particularly the leathern ladders in two parts or sides,—one for ascending and the other for descending.

Among the most interesting of the 413 excellent illustrations which alone would suffice to render this work one of unusual interest, is a series of views, reproduced from a print of the eighteenth century, showing the slate-quarries at Fumay. These are taken from the national library and have never before been published.

In addition to the cuts referred to there are given three colored plates and eight plates showing reproductions of medals. Both in its illustrations and in its presswork the book is a marvel of excellence.

NEW ROADS AND ROAD-LAWS IN THE UNITED STATES. By Roy Stone, Vice-President National League for Good Roads and United States Special Agent and Engineer for Road Inquiry, Department of Agriculture. New York: Van Nostrand [Cloth. 12mo. iv–166 pp. $1.50.]

THE general interest which has been awakened in the United States within the past few years in the subject of highway improvement is beginning to bear a considerable amount of fruit, both legislative and literary, and, what is even more to the purpose, work is actually in progress in some parts of the country under auspices which promise well for the future of this great national reform. Although not much can be said for either the literary or technical merit of the present treatise—and in fact it makes no pretensions to either—it nevertheless contains, in convenient and accessible form, a large amount of information which would otherwise have to be tediously sought for in scattered reports and ephemeral publications. The work comprises a compilation of extracts from these and other sources, giving a fairly complete account of the progress which has hitherto been made in road-improvement in different parts of the country, and a summary of road legislation, actual and prospective, in the various states. New Jersey and Massachusetts apparently have taken the initiative in this important matter, effective state aid being furnished in both cases, though under widely different provisions. In New Jersey work must be undertaken by the county authorities upon receipt of a petition of the owners of two-thirds the property fronting on the road, covering not less than one mile in length. One-third of the cost is defrayed by the state, one-tenth by the abutting owners, and the balance by the county and town. This law has been found to work admirably in practice, and an increasing length of roadway is being built under its provisions with each succeeding year. In Massachusetts the new roads are being built by the state under the supervision of the engineers of the state highway commission, the initiative being required to be taken, either by the county-commissioners or by the selectmen of a town, by petition to the commission. Upon the approval of the commission, not more than ten miles of state road may be built under petition in each county in each year, but the governor and council may in their discretion authorize this amount to be exceeded. One-fourth of the total amount expended in any county must be repaid to the state by that county within six years. According to advices received since the publication of this work more than 100 miles of improved road are to be constructed in Massachusetts before the close of the present year. Some of the best highways in the country, considering the small amount of money expended upon them (less than $1000 per mile), have been built in New York State under the provisions of the existing county-road law. It is pertinent, however, to remark that in this instance the supervisor appears to have been an engineer and not a hack politician. This book is handsomely illustrated with half-tone engravings, showing conspicuous examples both of good and bad roads, together with a number of working-drawings, illustrating modes of road-construction referred to in the text.

FRANKLIN L. POPE.

POPULAR LECTURES AND ADDRESSES. By SIR WILLIAM Thomson (Baron Kelvin), P. R. S., LL.D. D. C. L., Professor of Natural Philosophy in the University of Glasgow, and Fellow of St. Peter's College, Cambridge. Volume II—Geology and General Physics. London and New York: Macmillan. [Cloth. 8vo. 592 p. $2]

THIS is the last of three volumes, the first and third having preceded this in the order named. It consists of a compilation of the author's various papers relating to geological subjects and of lectures and addresses given by him between 1866 and the end of 1893, which were not included in Volumes I and III. While it thus contains nothing new, the many admirers of Lord Kelvin—and they are legion, for he is everywhere admitted to be the world's greatest living philosopher—will be glad to have these papers in handy form for reference and perusal. In treating of a work like this, criticism would be out of place and the reviewer will have done his work if he conveys to the mind of the reader a correct idea of the scope of the book. This can be best done by repeating the table of contents:

Polar Ice-Caps and their Influence in Changing Sea-Levels; On the Rate of a Clock or Chronometer as Influenced by the Mode of Suspension; On a New Astronomical Clock; On Beats of Imperfect Harmonies; On the Origin and Transformation of Motive Power; On the Sources of Energy in Nature Available to Man for the Production of Mechanical Effect; On the Dissipation of Energy; the Bangor Laboratories; Presidential Addresses; Address Delivered on the Occasion of the Unveiling of Joule's Statue in Manchester Town Hall, December 7, 1893; Isoperimetrical Problems; Protection of Vegetation from Cold; The Doctrine of Uniformity in Geology Briefly Refuted; Appendix

—Estimate of Present Annual Loss of Heat from the Earth ; On Geological Time ; Appendix—On the Observatories and Calculations Required to find the Tidal Retardation of the Earth's Rotation ; On Geological Dynamics—Part I, Reply to Professor Huxley's Address to the Geological Society of London, February 19, 1869. Part II, On the Origin and Total Amount of Plutonic Energy. Part III, Note on the Meteoric Theory of the Sun's Heat ; Presidential Address to the British Association, Edinburgh, 1871 ; Presidential Address to the Society of Telegraph Engineers, 1874 ; Review of Evidence Regarding the Physical Condition of the Earth ; Geological Climate ; The Internal Condition of the Earth as to Temperature, Fluidity and Rigidity.

This catalogue of important papers cannot fail to be of interest, in some of its numbers at least, to a large circle of readers, and they will find the text clear and heavily leaded, so as to be read without physical fatigue. The three volumes of which this is the second is the last addition to the "Nature Series."

THE USES OF COMPRESSED AIR. BY ADDISON C. RAND. Illustrated. New York : The Republic Press. [Cloth. 12mo. 134 p. $1.]

EVEN those who have closely watched the wonderful development of compressed-air systems will be surprised at the array of successful and important utilizations described by Mr. Rand. A simple enumeration of these uses would make a long list, but among the more prominent ones described are those of tunneling and mining by power drills, working and drilling in caissons, tapping iron-furnaces, the air-lift pumping system, air-brakes, operation of railway switches and signals, air-locomotives, street-cars, unloading cars, cranes, cutters and riveters, portable air-tools, synchronous clocks, coal-mining machines, air-guns, torpedo-guns, locomotive-torpedoes, transportation tubes, aërating fuel (petroleum, etc.), aërating water, refining asphalt, increasing the brilliancy of lamps, mixing nitroglycerin, pumping acids, etc., conveyance of sewage, raising sunken vessels, ice-making and refrigerating, pneumatic tires, general transmission of power, and so on, not forgetting the novel air-brush for painting large surfaces, which attracted so much attention during the preparatory stages of the World's Fair buildings. Mr. Rand presents the subject in an attractive, popular way. The book is attractively gotten up, with numerous and striking photo-engravings.

PRACTICAL INSTRUCTIONS IN QUANTITATIVE ASSAYING with the Blowpipe. Containing also readily applied Qualitative Blowpipe Tests. For the Prospector, Miner, and Assayer, and for use in Colleges. By E. L. Fletcher, U. S. A. New York : John Wiley & Sons. [Cloth. 12mo. 142 p.]

MORE can be accomplished with the blowpipe in the quantitative way than is generally supposed ; and, while there are thousands who understand the use of the blowpipe for making qualitative determinations, there are few who appreciate its capacity for quantitative assaying. A practical, simple, and cheap work like this is something that has long been in demand. The author introduces some new methods, which he recommends as more certain than those usually taught. By his system a large quantity of ore is operated upon, so that the outcome does not depend so much upon the skill, or want of skill, of the assayer. Wet methods are omitted. As the author justly says, they to a great extent destroy some of the distinguishing merits of the blowpipe—its quickness and simplicity.

THE MONEY OF THE UNITED STATES. BY MAURICE G. Muhleman, Cashier United States Sub-Treasury. New York : The *Safety Valve*. [Pamphlet. 70 p.]

THIS work contains an account of the money of the United States, which will be found a valuable compendium to those who have occasion to post themselves (1) upon legislative history of the various coins the and currencies of our country ; (2) the volume of money annually from 1873, the year in which the coinage system was reorganized, to 1893 ; and (3) the leading propositions submitted in congress and elsewhere for the solution of the currency problem.

A STUDY OF THE MONEY QUESTION. BY HUGO BILGRAM. New York : Humboldt Publishing Co.

THE author of this little book is a wide reader on economic subjects, and a close reasoner. He enjoys the distinction, too, among the men clamorous for more money.

of not believing in the vagaries of fiat money and other heresies of his school. When claiming the expediency of federal control over all the issues of money he has the good sense, also, to place it among the police- or commerce-regulating powers of the government. As to his theory, he seems to propose merely that all issues of money shall be convertible, not upon demand, but upon a time-limit protected by insurance, thereby creating a larger volume of what he calls credit-money. Well, this might work, too, but of what use would it be? We have more money now than we know how to use. Say that there are 20,000,000 persons in the United States,—which there are not,—on weekly wages or salaries to be paid every Saturday night. Say, also, that the average income of these persons is $3 a day, which it is not again, and it would take $360,000,000 for use each Saturday. But all this money returns to the banks again during the week following through the various channels of commerce and might be used fifty-two times in a year for the same purpose. As to the money passing between merchants, or between merchants and manufacturers, it is only used, as every one knows, in the settlement of balances. This method of estimating, and not foolish estimates on per capita circulation, is the way to find the amount of money needed. It is a merely mechanical question. England does a much larger commercial business than France with only about one-third the money that France uses.

We do not need more money, but we do need a more flexible currency, better protected in the machinery for its distribution. When depression comes, money begins to flow away from the extremities and to seek the financial centers, and panic finally develops a clear case of congestion. But no increase in the amount of federal currency would check this tendency. The remedy must be found in decentralization, in the local power of issuing money secured on local property. Hence the demand for the repeal of the state-bank tax, caused by the prevailing financial disasters.

WILLIAM NELSON BLACK.

NEW BOOKS OF THE MONTH.

Practical Electrics.=A universal handy-book on every-day electrical matters. New York: Spon & Chamberlain. [Cloth. 8vo. 3-135 p. 75 cents.]

Preston, T.=The Theory of Heat. New York: Macmillan. [Cloth. 8vo. 719 p. $5.50, net.]

Revill, Alfred.=American Plumbing. For master plumbers, architects, builders, apprentices, and house-holders. A complete compendium of practical plumbing, from solder-making to high class open work. Illustrated. New York: Excelsior Publishing House. [Cloth. 12mo. 255 p. $2.]

Rigg, Arthur.=A Practical Treatise on the Steam-Engine. Illustrated. Second edition. New York: Spon & Chamberlain. [Cloth. 24 = 379 p. $10.]

Rigg, A., *and* Garvie, J.=Modern Guns and Smokeless Powder. Influence of modern explosives upon modern guns. New York: Spon & Chamberlain. [Paper. 8vo. 83 p. $2.]

Rosewater, Frank.=A Romance of Utopia. A solution of the labor problem. Omaha, Neb. [Paper. 8vo. 268 p. 50 cents.]

Salomons, Sir David.=Electric Light Installations. Vol. II—Apparatus: a practical handbook. Seventh edition. Illustrated. New York: Van Nostrand. [Cloth. 12mo. 16-318 p. $2.25.]

Schaffle, A.=The Theory and Policy of Labor Protection. Edited by A. C. Morant. New York: Scribner. [Cloth. 12mo. 252 p. $1.]

Seligman, Edwin R. A.=Progressive Taxation in Theory and Practice. Baltimore, Md.: American Economic Association. [Paper. 8vo. 222 p. $1.]

Sheffield, O. H.=Improvement of the Road System of Georgia. (Bulletin No. 3, Office of Road Inquiry, United States Department of Agriculture.) Washington: Government Printing Office. [Paper. 8vo. 31 p. no price.]

Stone, Roy.=New Roads and Road Laws in the United States. New York: Van Nostrand. [Cloth. 12mo. 7-166 p. $1.50.]

Thompson, Langdon S.=Educational and Industrial System of Drawing. Illustrated. Boston: D. C. Heath & Co. [Seven series. Paper. 8vo. 25 to 60 cents, *each.*]

Waring, George E., Jr.=Modern Methods of Sewage Disposal for Towns, Public Institutions and Isolated Houses. New York: Van Nostrand. [Cloth. 12mo. 6-252 p. $2.]

Webb, Sidney *and* Beatrice.=The History of Trade-Unionism. New York: Longmans, Green & Co. [Cloth. 8vo. 16-558 p. $5.]

World's Columbian Exposition.=Official Illustrated Publication. Art and Architecture, in Thirty Parts, by William Walton. Philadelphia: George Barrie. [Folio, $1 per part.]

Young, Francis Chilton, *editor.*=Electrical Apparatus for Amateurs. New York: Ward, Locke, & Bowden, Limited. [Cloth. 8vo. 104 p. 40 cents.]

NEW TRADE CATALOGUES.

Any of these catalogues free on application to the manufacturer.

The Dayton Globe Iron Works Co., Dayton. Ohio.=Power-Transmitting Machinery. 105-iv, p. [Contains in addition to the price-lists and illustrations, rules for calculating size and speed of pulleys, descriptive tables of gearing, journal-boxes, hangers, etc. It bears evidence of care in compilation, and will prove of value to those interested.]

Farrel Foundry and Machine Company, Ansonia, Conn.=Ore- and Rock-Crushing Machinery. 34 p. [Illustrations and descriptive matter of ore- and stone-crushers, crushing-rolls, mortar-mills, together with sectional views of ore-crushing and washing plants concisely described.]

H. W. Caldwell & Son Company, Chicago.=Elevating, Conveying and Power-Transmitting Machinery. 186 p. [An exhaustive publication descriptive of specialties made.]

Gifford Brothers, Hudson, N. Y.=Founders and Machinists. 40 p. [Contains in concise form description and price-lists of couplings, shaftings, friction clutches, etc., also tables and rules for determining horse-power of pulleys and engines.]

J. S. Mundy, Newark, N. J.=Hoisting, Bridge-Erecting, Pile-Driving, Logging and Mining Engines, etc. 72 p. [A carefully prepared catalogue setting forth the merits of the products of this well-known firm.]

Westinghouse Electric and Manufacturing Company, Pittsburgh.=The Wurts Non Arcing Railway Lightning Arrester, with practical hints on means for protection against lightning. 45 p. [A brief description of the discovery of non-arcing metal, together with a statement of the fundamental principles underlying its application. The hints contained are timely and practical, and aside from its value, the publication is a typographical gem.]

Interior Conduit and Insulation Company, New York.=Lundell Dynamos and Motors. 24 p. [Description of the Lundell dynamos and motors, with rules for their installation and use.]

The Cincinnati Corrugating Co., Cincinnati. =Corrugated roofing, corrugated lath, metallic weather boards, etc. 63 p. [Full description of the various products of the company with instructions as to use and rules for estimating quantities.]

Jenkins Brothers, New York.=Trade catalogue of valves, packing, etc. 68 p. [Contains full descriptions with price-lists, tables of dimensions, etc.]

A. Weiskittel & Son, Baltimore, Md.=Fire King Gas Stoves and Ranges, 51 p. [Descriptive of gas stoves and ranges, with an argument for the use of gas as fuel.]

Jarecki Manufacturing Company, Limited, Erie, Pa.=Malleable Cast Iron Fittings, Valves, Cocks, etc. 300 p. [Comprehensive descriptive catalogue of products manufactured, carefully compiled and indexed.]

Knowles Steam Pump Works, New York.=Power Pumps for Paper and Pulp Mills. 31 p. [A special publication descriptive of machinery for paper-manufacturers.]

The Westinghouse Air-Brake Co., Pittsburgh. =The Westinghouse Automatic Air-Brake. 78 p. [Modern brake appliances fully described, with copious illustrations. A handsome trade publication designed mainly for use of railway employés who have occasion to order air-brake supplies.]

Smith & Anthony Company, Boston, Mass. =Sanitas Plumbing Appliances. 64 p. [Complete and handsome catalogue of plumbing appliances, valuable to those interested.]

American Fuel Economizer and Engineering Company, New York.=Heating and Purifying Feed Water. 37 p. [Descriptions of fuel economizers, with suggestions for their care and arrangement; also useful data for engineers and steam-users.]

H. E. Olbrich, Cedar Falls, Ia.=Replogle's Electric Regulators. 15 p. [General description of electric regulators for water-power users.]

The Hornberger Electric Manufacturing Company, Elkhart, Ind.=The Elkhart Transformer, Tooth Type.

American Saw Company, Trenton, N. J.=Saws and Saw-makers' Tools. 35 p. [Full description of various articles in the sawmakers' line.]

C. M. Kemp Manufacturing Company, Baltimore, Md.=The Climax Gas Machine and Gas Mixer. 48 p. [Descriptive of Gas-machines, mixers, and kindred apparatus.]

Miamisburg Electric Company, Miamisburg, Ohio.=Imperial dry battery and Burnley Cartridge Battery.

Henry Maurer & Son, New York.=Fire-Proof Building Materials. [Fully descriptive of materials, with illustrations of prominent buildings constructed.]

Kansas City Metal Roofing and Corrugating Company, Kansas City, Mo.=Corrugated Iron, Metal Shingles, etc. 32 p.

Rumsey & Co., Limited, Seneca Falls, N. Y. =Hydraulic and Pumping Machinery. 171 p. [Forty-ninth edition. Comprehensive publication containing descriptions of various hand and power pumps, hydraulic machinery, etc., manufactured.]

American Tube Works Company, Boston, Mass.=Brass Pipe. 32 p. [Of special interest to builders and plumbers.]

Rue Manufacturing Company, Philadelphia. =Injectors, Ejectors, and other Jet Apparatus. 16 p. [Descriptive price-lists of boiler-washing and testing apparatus, injectors, steam-valves, and kindred appliances.]

Gisholt Machine Company, Madison, Wis.=Modern Turret Lathe Practice. May edition; issued monthly. [Contains description of turret lathe machine work which will prove of interest to those concerned.]

[*For additional catalogues see "Improved Machinery," page 28 b.*]

THE·TECHNICAL·INDEX

A CATALOGUE OF LEADING ARTICLES PUBLISHED CURRENTLY IN THE TECHNICAL JOURNAL OF THE UNITED STATES AND GREAT BRITAIN.

THIS publication has been aptly described as "the greatest step that has been taken in recent years towards systematizing work" for the engineer, the architect, the electrician, the railway manager, and the business man. The list of publications regularly indexed will show that it covers a world-wide range of the best technical literature, and all the articles are so conveniently classified under general headings that within a few minutes an active man can learn of everything that has been published during the month in relation to his special lines of investigation. In short, it is to the practical man just what Poole's celebrated index to periodicals has long been to the literary worker, but with this essential difference,—namely, that in addition to indicating *just where* leading articles have been published, *we undertake to supply copies of the articles themselves.* The unparalleled convenience and economy of this double service can readily be appreciated.

IN ordering articles from us, care should be taken to give the *number*, not the title alone. The price of a single article is 15 cents, excepting those indicated by an asterisk (*), 30 cents, and by a dagger (†), 45 cents—according to the price of the publication quoted. All orders *must* be accompanied by cash or stamps.

To avoid frequent remittances and to cheapen the cost of articles to those who order largely, we sell coupons at the rate of 15 cents each, or 15 for $2, 40 for $5, and 100 for $12.50. Each coupon is receivable in exchange for one 15-cent article; those marked * require two coupons, and those marked † require three coupons. This system is strongly commended. The coupons need only a trial to demonstrate their great convenience and economy of time and money.

[In the body of the index only the initials of the journals quoted are given, and these can be readily identified by the following list of periodicals. Other abbreviations are: Ill=Illustrated. w=words.]

THE AMERICAN PRESS.

A ....Arena. *m.* $5 per year. Boston.
AA......American Architect. *w.* $6. Boston.
An A A..Annals of Am. Academy of Political and Social Science. *b-m.* $6. Philadelphia.
A An.... American Analyst. *f.* $1. New York.
A Ar.... American Artisan. *w.* $2. Chicago.
A & B....Architecture and Building. *w.* $6. N. Y.
A B D....Architect, Builder and Decorator. *m.* $2. Minneapolis.
A CJ....Am. Chem. Journal. *b-m.* $4. Baltimore.
A E R J.Am. Eng. and Railroad Journal. *m.* $3. N.Y.
A G......Am. Geologist. *m.* $3.50. Minneapolis.
A G L J..Am. Gas Light Journal. *w.* $3. New York.
A H......Annals of Hygiene. *m.* $2. Phila.
A J Phar.Am. Journal of Pharmacy. *m.* $3. Phila.
A J R A..Jour. R'y. Appliances. *m.* $2. New York.
A M......American Machinist. *w.* $3. New York.
A M & I W.Am. Man. and Iron World. $4. Pittsburg.
Am S....American Shipbuilder. *w.* $2. New York.
A & N J..Army and Navy Journal. *w.* $6. New York.
A & N R..Army and Navy Register. *w.* $3. Wash'ton.
A R......Architectural Record. *q.* $1. New York.
A Rev....Architectural Review. *s-q.* $5. Boston.
A S......Age of Steel. *w.* $3. St. Louis.
B B......Brick Builder. *m.* $2.50. Boston.
B C......Boston Commonwealth. *w.* $2.50. Boston.
B G S....Bul. Am. Geog. Soc. *q.* $5. New York.
B I S.....Bul. Am. Iron and St. Asso. *w.* $4. Phila.
B J C....Boston Jour. of Commerce. *w.* $3. Boston.
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E E......Electrical Engineering. *m.* $1. Chicago.
E E N Y..Electrical Engineer. *w.* $3. New York.
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E M......Engineering Mechanics. *m.* $2. Phila.
E Mag...Engineering Magazine. *m.* $3. New York.
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E R N Y..Electrical Review. *w.* $3. New York.
E & R....Elec. and Railroading. *m.* $1. Boston.
E S W P...Proc. Eng. So. of W.Pa. *m.* $7. Pittsburg.
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F ....Forum. *m.* $3. New York.
F D......The Foundry. *m.* $1. Detroit.
F W......Fire and Water. *w.* $3. New York.
G & F....Garden and Forest. *w.* $4. New York.
G G M...Goldthwaite's Geograp. Mag. *m.* $2. N.Y.
G R......Good Roads. *m.* $2. New York.

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Ir Age..Iron Age. *w.* $4.50. New York.
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I R W...India Rubber World. *m.* $3. New York.
I S F.....Industry. *m.* $2. San Francisco.
I T R....Iron Trade Review. *w.* $3. Cleveland.
J A... ..Journal of Architecture. *m.* $2. Phila.
J A C S..Jour. Am. Chem. So. *m.* $5. Easton.
J A E S. Jour. Assoc. Eng. Soc. *m.* $3. Chicago.
J A N E..Jour. Am. Soc. Naval Engineers. *qr.* $5. Washington.
J F I.....Jour. Franklin Institute. *m* $5. Phila
J M S I..Jour. Milit. Service In. *b-m.* $4. NewYork.
J N E W.Jour.N.E Waterw. As. *q.* $2. New London.
J P E.....Jour. Polit. Economy. *q.* $3. Chicago.
J U S A..Jour. U. S. Artillery. *q.* $2.50. Ft. Monroe.
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L Mag...Lippincott's Magazine. *m.* $3. Phila.
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M & El...Mech. and Electrician. *w.* $2. St. Louis.
Met W...Metal Worker. *w.* $2. N. Y.
M G......Manufacturer's Gazette. *w.* $3. Boston.
Mill......Milling. *m.* $2. Chicago.
Min......Minerals. *m.* $1. N. Y.
Min. R...The Mining Review. *w.* $2. Denver.
M I T....Mining Industry. *w.* $3. Denver.
M N.....Mechanical News. *s-m.* $1.50. New York.
M R......Manufacturer's Record. *w.* $4. Baltimore.
M R C...Marine Review. *w.* $2. Cleveland, O.
M Rec....The Marine Record. *w.* $2. Cleveland.
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M S R....Mining and Sci. Review. *w.* $2. Denver.
N A R...North American Review. *m.* $5. N. Y.
N B .....National Builder. *m.* $3. Chicago.
N C B...National Car Builder. *m.* $2. New York.
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N W.....Nowest. Architect. *m.* $3. Minneapolis.
O P D R..Oil, Paint and Drug Reporter. *w.* $6. N.Y.
P...... ..Paving. *m.* $2. Indianapolis.
P A......Progressive Age. *s-m.* $3. New York.
P E C P.Procd. Engineer's Club. *q.* $2. Phila.

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P S M....Popular Science Monthly. *m.* $5. N. Y.
R A.....Railway Age. *w.* $4. Chicago.
R C J....Railroad Car Journal. *m.* $1. New York.
R E M....Railway Engineering and Mechanics. *m.* $1. Chicago.
R G .....Railroad Gazette. *w.* $4.20. N. Y.
R M.....Roller Mill. *m.* $2. Buffalo, N. Y.
R of R...Review of Reviews. *m.* $2.50. New York.
R R......Railway Review. *w.* $2. Chicago.
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R'y N....Railway News. *m.* $2. New York.
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S J E....Sibley Jour. of Eng. *m.* $2. Ithaca, N. Y.
S M.....ScientificMachinist.*s-m.*$1.50. Cleveland,O.
So L.....Sou. Lumberman. *s-m.* $2. Nashville.
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S R E N..St. R'y. Elec. News. *m.* $2. Minneapolis.
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S R G....Street Railway Gazette. *w.* $3. Chicago
S R J....Street Railway Journal. *m.* $4. New York.
S R N....Street Railway News. *w.* $3. New York.
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T A I E E.Trans. Am. Ins. Elec. Eng. *m.* $5. N Y.
T C E....Trans. Am. Soc. Civil Eng. *m.* $10. N. Y.
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Tr A M E.Trans. Am. Ins. of Mining Eng. N. Y.
T W A...Trans. of the Wis. Acad. Madison.
W E......Western Electrician. *w.* $3. Chicago
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EngL... Engineer. *w.* 36*s.* London.
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R N......Railway News. London.
R P L....The Railway Press. *m.* 7*s.* London.
R R L...The Railway Review. *w.* London.
R W.....Railway World. *m.* 5*s.* London.
S L......Steamship. *m* Leith, Scotland.
S R......Sanitary Record. *m.* 10*s.* London.
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ELECTRIC LIGHTING.

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*19695. The Goebel-Munchhausen Lamp Story. A. M. Tanner (E R L–Feb. 2.) 1800 w.

*19702. Faulty Wiring of Vessels (E E L–Feb. 2.) 550 w.

*19704. Charging Station for Automatic Railway Carriage Lamps. Ill. (E E L–Feb. 2.) 1200 w.

19733. Long Distance Transmission with Alternating Currents. Ill. Frank C. Perkins (E W–Feb. 17.) 450 w.

*18616. The Kingston Corporation Electric Lighting Station. Ill. (E E L–Feb. 9.) 1400 w.

*19820. The Underground Electric Light Mains in the City of Glasgow. Willliam Lackie (E E L–Feb. 9.) 5000 w.

19927. Still Another Lamp. Julian A. Moses (E R N Y–Feb. 21.) 700 w.

*19933. The Arc Lamp. Ill. (E I–Feb.) 6000 w.

19978. Electrical Effects at the Chicago Scenitorium. Ill. (W E–Feb. 24.) 2600 w.

20040. The New First District Station of the Edison Electric Illuminating Company of Brooklyn. Ill. (E E N Y–Feb. 28.) 1200 w.

20041. The Adaptability of an Edison Three-Wire Plant. Ill. James Milne (E E N Y–Feb. 28.) 700 w.

*20044. The First Three-Phase Transmission Plant in the United States. Redlands, Cal. Ill. (E R L–Feb. 16.) 2000 w.

*20050. The St. Pancras Electric Lighting Station, with Discussion. Henry Robinson (J S A–Feb. 16.) 6200 w.

20094. The Last Two Decades in Arc Lighting. Edwin J. Houston (E W–March 3.) 1200 w.

20095. The Growth of Incandescent Lighting. W. A. Anthony (E W–March 3.) 1100 w.

20102. The Loss of Light from the Use of Globes with Arc Lamps. George D. Shepardson (E W–March 3.) 600 w.

20103. Boilers for Small Central Stations. Reginald A. Fessenden (E W–March 3.) 1300 w.

20104. Comparative Value of Certain Wiring Plans and some Wiring Pointers. E. P. Roberts (E W–March 3.) 1000 w.

20105. Economy of Incandescent Lamps. W. Stuart Smith (E W March 3.) 1800 w.

20134. Specifications for Arc Street Lighting Plant, Detroit, Mich. (E N–March 1.) 4800 w.

*20265. Jerry Wiring for Ships. Ill. (E R L–Feb. 23.) 1300 w.

20270. Faults Incident to the Protection of Lighting and Power Circuits. Lucius T. Stanley and Walter E. Harrington (E R N Y–March 7.) 2700 w.

20276 The Cost of Producing Electricity.—Report of the Committee of the National Electric Light Association (P S–March.) 700 w.

20283. Photometry. A. W. Clapp (E W–March 10.) 800 w.

20284. Arc Lamps on Incandescent Circuits. — Discussion. — Opened by L. B. Marks (E W–March 10.) 1000 w.

20285. Development of Switchboards for Modern Central Stations (E W–March 10.) 2500 w.

Serials.

6709. Electric Light and Power. Arthur F. Guy (E E L–Began Sept. 9, 1892—36 parts to date—30 cts. each).

19819. Some Notes on the Electric Lighting of the City of London. Major-Gen. Webber. (E E L–Began Feb. 9—3 parts to date—30 cts. each).

20045. Rules and Regulations for Electric Lighting Steamships. Rankin Kennedy. (E R L–Began Feb. 16—2 parts to date—30 cts. each).

20247. The Nottingham Municipal Electricity Works. Ill. (E E L–Began Feb. 23—1 part to date—30 cts).

GAS ENGINEERING.

19647. Gas Combustion and Temperatures. J. P. G. (A G L J–Feb. 12.) 1000 w.

*19721. Gas as a Sanatarian. (Abstract.) Lynn Cyril D'Oyle (G W–Feb. 3.) 4400 w.

*19772. The Coal Elevating and Conveying Machinery at the Elland Gas Works. (J G L–Feb. 6) 1000 w.

19781. The East River Gas Undertaking, with Editorial. Ill. (P A–Feb. 15.) 12000 w.

19782. The Treatment of Ammonia Liquor. Herr. Blum (P A–Feb. 15.) 1000 w.

*20008. The Gas Supply of Manchester. J. W. Southern (G E M–Feb. 10.) 1000 w.

*20009. Donkin on Internal Combustion Motors. (J G L–Feb. 13.) 1700 w.

*20144. Inaugural Address of H. Smythe. (J G L–Feb. 20.) 4800 w.

*20145. Inaugural Address of R. O. Patterson (J G L–Feb. 20.) 3800 w.

20205. Advantages of a Combined Coal and Water Gas Plant, with Discussion. C. J. R. Humphreys (A G L J–March 5.) 7200 w.

*20231. Artificial Illumination (I C B–Feb. 23.) 2000 w.

*20345. Is a New Gas Undertakings Association Desirable? (J G L–Feb. 27.) 2000 w.

*20346. A New Method of Valuing Illuminating Gas. John T. Sheard (J G L–Feb. 27.) 1700 w.

Serials.

13534. The Gas Engine. Ill. (M W–Began June 2, 1893—7 parts to date—30 cts. each).

19650. The Chemical Technology of Coal Gas. Vivian B. Lewes (J G L–Began Jan. 30—5 parts to date—30 cts. each).

19815. Gas for the Household. William Paul Gerhard (D E-Began Feb.—1 part to date—30 cts).

20143. The Action of Heat upon Ethylene. Vivian B. Lewes (J G L-Began Feb. 20—2 parts to date—30 cts. each).

HYDRAULICS.

*19636. Experiments on Two Forms of Hydraulic Rams. Ill. R. C. Carpenter (E M-Feb.) 400 w.

19770. The South Yuba Water Company. Ill. (M S P-Feb. 10.) 2200 w.

*19801. Storage Capacity in Lakes and Reservoirs. Ill. Elon Huntington Hooker (S J E-Feb.) 2500 w.

*19864. The Cost of Water Power. Editorial (I & I-Feb. 9.) 600 w.

19962. Water Tube Boilers for the St. Louis Water Works (E N-Feb. 22.) 1450 w.

19963. Driven Wells on the Plainfield Water Supply System. (Abstract) Louis L. Tribus (E N-Feb. 22.) 1000 w.

20012. Filter at the Wannacomet Water-Works, Nantucket, Mass. Ill. (E. R-Feb. 24.) 1200 w.

*20067. Storage Reservoirs on the Nile. Editorial (E-Feb. 16.) 2800 w.

20132. Outlet Gates of the Beetalo Water-Works Reservoir, South Australia. Ill. (E N-March 1.) 600 w.

20177. Rome's Beautiful Water Supply. (Abstract.) Prof. Burton (F W-March 3.) 2000 w.

*20281. The Berry Tangential Water Wheel Buckets. Ill. A. E. Chodzko (I S F-March.) 1400 w.

20324. Southern Water-Powers and Their Future Utilization. W. J. Thalkston (M R-March 9) 900 w.

20353. Thc Lowell Water System. Ill. (F W. March 10.) 2500 w.

Serials.

18396. Notes on Artesian Water, and the Effects of Irrigation on Sub-Surface Water in the San Joaquin Valley. C. E. Grunsky (E R-Began Dec. 23—4 parts to date—15 cts. each).

18676. The Pumping Engine; Its Many Points, Faults and Peculiarities. Ernest W. Naylor (F W-Began Jan. 6—9 parts to date—15 cts. each).

18801. Discharge of Sluices and Weirs under Varying Heads. Ill. G. C. Maconchy (I E-Began Dec. 9—4 parts to date—45 cts. each).

20126. The Water Supplies in the Arid Regions. J. W. Powell (M S P-Began Feb. 24—2 parts to date—15 cts. each).

INDUSTRIAL CHEMISTRY.

†19646. An Exact Determination of Phosphorus by a Molybdate Method in Iron, Steel and Ores which Contain Arsenic. James O. Handy (E S W P-Dec.) 1000 w.

*19811. Bleach and Caustic by Electrolysis (C T J-Feb. 10.) 1800 w.

*19850. The Electrolysis of Salts of the Alkali Metals. Bertram Blount (El-Feb. 9.) 800 w.

†20002. Determination of Nickel in Nickel-Steel. E. D. Campbell (J A C S-Feb.) 2100 w.

†20003. Experiments on the Estimation of Graphite in Pig Metal. Frank L. Crobaugh (J A C S-Feb.) 1000 w.

†20004. Notes on Determination of Nickel in Steel. Joseph Westesson (J A C S-Feb.) 700 w.

†20005. Experiments on the Analysis of Pig Copper, Brasses and Bronzes. James S. de Benneville (J A C S-Feb.) 2000 w.

†20138. Slag Cement Experiments. R. W. Mahon (J F I-March.) 1500 w.

†20139. A Remarkable Artesian Well Water. Reuben Haines (J F I-March.) 1400 w.

*20249. An Example of Modern Chemical Engineering.—Messrs. Price's Patent Candle Company, Limited. Ill. (I & I-Feb 23.) 9200 w.

Serials.

11891. Water Analysis. George C. Tilden (Sc Q-Began March, 1893—3 parts to date—45 cts. each).

17576. Theoretical and Practical Ammonia Refrigeration. Iltyd I. Redwood (Eng-Began Nov. 25—8 parts to date—15 cts. each).

INDUSTRIAL SOCIOLOGY.

19626. The Wilson Bill.—Abstract of Hon. T. B. Reed's Great Speech (M G-Feb. 10.) 1300 w.

19627. Railway Corporations Using Every Effort to Keep New England Industries from Having Free Coal (M G-Feb. 10.) 2000 w.

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†19748. Prospects of Free Trade in the United States. Chauncey M. Depew (N C-Feb.) 5500 w.

19854. The Negro as an Industrial Worker. Hugh M. Browne (T-Feb. 15.) 2500 w.

*19868. Domination in Labor Questions. Editorial (E-Feb. 9.) 1000 w.

19903. The Loaf of the Unemployed. Editorial (A S-Feb. 17.) 1000 w.

*19935. The Workingmen's Colonies of Germany. Emily M. Burbank (Ch-March.) 4300 w.

19938. The Danbury Lesson. A. B. Salom (I I G-Feb.) 1100 w.

†19993. Natural Monopolies and the Workingman.—A Programme of Social Reform. Richard T. Ely (N A R-March.) 4200 w.

†19994. Home Industries and the Wilson Bill. Charles Stewart Smith, Edward Kemble, A. K. Miller, W. H. Dimond (N A R-March.) 5500 w.

20196. A Comparison Between the Condition of Laborers in the South and in Europe. William M. Brewer (T–March.) 2000 w.

*20298. The Causes of Industrial Depression. T. W. Graham (Mill–March.) 1000 w.

†20309 The Cause of Financial Panics. J. W. Bennett (A–March.) 13400 w.

LANDSCAPE ENGINEERING.

19726. Where the Work of the Landscape Gardener Should Begin. H. A. Caparn (G & F–Feb. 14.) 750 w.

20273. Vegetable Sculpture in China. A. B. Westland (G & F–March 7.) 1300 w.

Serials.

19346. Public Squares. Ill. T. M. Newton (A A–Began Feb. 3—4 parts to date—15 cts. each).

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*19664. Sealing in Open Waters. John Milne (K–Feb. 1.) 1800 w.

*19670. Port Elizabeth Harbor.—The Liverpool of South Africa (Tr–Feb. 2.) 1500 w.

*19684. The Position of Marine Engineers. Editorial (E–Feb. 2.) 2600 w.

*19693. The Twin-Screw Steamer "Southwark." Ill. (Eng L–Feb. 2.) 1200 w.

*19701. Screw Propellers, and Non Reversible Engines, with Discussion. Robert M'Glasson (S L–Feb.) 8000 w.

*19722. Diving and Salvage. Ill. (E G–Feb.) 1500 w.

19728. The Finest Pier in America.—"American Line" Pier. Ill. (E E N Y–Feb. 14.) 3000 w.

19768. The American Steamship "Savannah."—The First Ship to Cross the Western Ocean under Steam. Ill. (Am S–Feb. 15.) 1000 w.

19847. A Patent Attorney's Defense of the Whalebacks. Frank L. Dyer (M R C–Feb. 15.) 1200 w.

*19866. Discussion of T. Hudson Beare's paper.—"Abstract of the Results of Experiments in Six Steamers, and Conclusions Drawn Therefrom in Regard to the Efficiency of Marine Boilers and Engines" (E–Feb. 9.) 10000 w.

*19871. The Transport of Petroleum in Bulk. Boverton Redwood (E–Feb. 9.) 1600 w.

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*20077. Shipping and Commerce at Adriatic Ports (Tr–Feb. 16.) 1200 w.

*20078. The First Dry Dock at Manchester (Tr–Feb. 16.) 1000 w.

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20203. The Captain of an Ocean Tramp (M Rec–March 1.) 550 w.

†20256. Comparison of Typical Ocean Steamers. J. M. Lincoln (J A N E–Feb.) Table.

20313. Fithian Free-Ship Fallacies (Sea–March.) 4200 w.

20319. The Fellows Steam Steering Gear. Ill. (Am S–March 8.) 900 w.

Serials.

19094. On Piratical Seas.—A Merchant's Voyage to the West Indies in 1805. Peter A. Grotjan (Sc M–Began Feb.—2 parts to date—30 cts. each).

19292. Apparatus for Rapid Loading of Coal into Ships. Ill. G. Braet (A E R J–Began Feb.—2 parts to date—30 cts. each).

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19872. Marine Engine Trials.—Abstract of Results of Experiments on Six Steamers, and Conclusions Drawn Therefrom in Regard to the Efficiency of Marine Boilers and Engines. T. Hudson Beare (E–Began Feb. 9—Ended Feb. 23—2 parts—30 cts. each).

19940. Water Tube Marine Boilers. W. A. Carlile (Am S–Began Feb. 22—3 parts to date—15 cts. each).

20142. The Resistance of Ships. Richard Lano Newman (J F I–Began March—1 part to date—45 cts).

20217. The Belgian Government Mail Steamer "Marie Henriette." Ill. (E–Began Feb. 23—1 part to date—30 cts).

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19655. Business Essentials. B. F. Spalding (A S–Feb. 10.) 1900 w.

*19659. Power Transmission by Leather Belts. C. R. Tompkins (Mill–Jan.) 1300 w.

*19660. The Evolution of the Air-Belt Purifier. Ill. (Mill–Feb.) 1000 w.

*19723. An Era of Mechanical Triumph. Robert H. Thurston. (E G–Feb.) 2500 w.

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19804. Polishing a Large Stone Column. Ill. (E R–Feb. 17.) 1400 w.

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*20039. The Livét Refuse Utilizer and Steam Generator. Ill. (El–Feb. 16.) 2200 w.

*20058. Vibration and the Vibromotor. Editorial (I & I–Feb. 16.) 1500 w.

†20136. Schuman's Process and Apparatus for Embedding Wire Netting in Glass. Ill. (J F I–March.) 5000 w.

†20254. Modern Cranes. Ill. B. H. Warren (J A N E–Feb.) 18500 w.

20287. Compressed Air Transmission. Frank Richards (A M–March 8.) 1250 w.

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14879. The Battle of the Typewriters. Ill. (Inv–Began July 29—Ended Feb. 24—10 parts—30 cts. each).

16781. Rope Driving. J. J. Flather (E W–Began Oct. 21—9 parts to date—15 cts. each).

17900. Machine Shop Milling Practice. Ill. Horace L. Arnold (A M–Began Dec. 7—7 parts to date—15 cts. each).

18044. Motive Power and Gearing. E. Tremlett Carter (El–Began Dec. 1—9 parts to date—30 cts. each).

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20171. Practical Notes on Rope Driving. M. E. (S R J–Began March—1 part to date—45 cts).

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*19617. Pyritic Smelting. Philip Argall. (E Mag–April.) 3000 w.

*19720. Wire: Its Invention and Uses, and British Retrogression (Inv–Feb. 3.) 3000 w.

19738. Items About Blacksmithing. B. F. Spalding (A. M–Feb. 15.) 3000 w.

19780. Steel Plate Rolling in Great Britain. William Muirhead (Ir Age–Feb. 15.) 2800 w.

19784. Handling Steel Products by Electrical Power. Ill. (W E–Feb. 17.) 800 w.

19810. Close Sizing before Jigging in Ore Concentrations. Robert H. Richards (E M J–Feb. 17.) 1000 w.

*19842. A Decaying Industry in the North of England (C G–Feb. 9.) 1200 w.

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*19873. The Corrosion of Iron and Steel, with Discussion. Thomas Turner (I C T–Feb. 9.) 5000 w.

*19874. The Vicissitudes of the American Iron Industries (I C T–Feb. 9.) 1200 w.

†19911. Metallurgical Lead Exhibits at the Columbian Exposition. Ill. H. O. Hofman (T Q–Oct.) 5000 w.

*19916. The MacArthur-Forrest Patent To Be Disputed in South Africa (A M S–Dec. 30.) 700 w.

*19922. The Gold and Silver Question. Thomas Cornish (A M S–Jan. 13.) 2500 w.

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20032. Chlorination of Gold Ores in California. G. F. Deetken (M S P–Feb. 17.) 1350 w.

*20059. The Soundness and Working Qualities of Crucible Steel. F. Korb and Thomas Turner (I & I–Feb. 16.) 3200 w.

20085. An English Estimate of the Iron and Steel Trade.—Report of Bolling and Lowe, of London, Eng. (R R–Feb. 24.) 1600 w.

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*20224. Economy of Steam in Rolling Mill Engines, with Discussion. (Abstract.) Mr. Worth (C G–Feb. 23.) 3000 w.

*20230. Influence of Chemical Agents in Producing Injury to Iron and Steel. (Abstract.) William Thomson (P Eng–Feb. 23.) 4000 w.

†20258. The Application of Electrolysis to Qualitative Analysis. Charles A. Kohn (Sc Q–Sept. and Dec.) 2000 w.

†20259. Some Observations of a Practical Mill Man. C. E. Dewey (Sc Q–Sept. and Dec.) 1800 w.

†20261. The Assay of Gold. T. K. Rose (Sc Q–Sept. and Dec.) 900 w.

20275. Engine Forgings. (Extract.) Russell W. Davenport (P S–March.) 1500 w.

†20302. Product and Economical Results of the Marsac Refinery for the Year 1892. C. A. Stetefeldt (Tr A M E–Feb.) 3000 w.

†20304. The Stetefeldt Furnace. Ill. C. A. Stetefeldt (Tr A M E–Feb.) 5000 w.

†20305. Solids Falling in a Medium.—Their Incipient and Maximal Velocities.—A Study for Ore Concentrators. F. W. F. Cazin (Tr A M E–Feb.) 5000 w.

20310. Furnace vs. Foundry Practice, with Discussion. E. A. Wheeler (Ir Age–March 8.) 2800 w.

20311. A Foundryman on Foundry Chemistry. Simpson Bolland (Ir Age–March 8.) 4300 w.

20326. Roasting Southern Ores (M R–March 9.) 850 w.

20329. Limitations of the Gold Stamp Mill.—Discussion by Phillip Argall on paper by T. A. Rickard (M S P–March 3.) 2000 w.

20342. The Ore Washing Plant at Longdale, Virginia. Ill. Guy R. Johnson (E M J–March 10.) 1000 w

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19215. Canadian Iron Industry. George E. Drummond (C Eng–Began Jan.—2 parts to date—15 cts. each).

19300. Elasticity and Fluidity.—The Methods that Are Employed in Making Steel Tubes

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19336. Gold Milling in Australasia. T. A. Rickard (E M J-Began Feb. 3—Ended Feb. 10—2 parts—15 cts. each).

19482. A New Process for the Production of Pig Iron, Refined Iron, Ingot Metal and Weld Metal. Ill. Alexander Sattmann and Anton Homatsch (C G-Began Jan. 26—Ended Feb. 9—3 parts—30 cts. each).

19638. Blowing Engines and Machinery. Albrecht von Ihering (E M-Began Feb.—1 part to date—30 cts).

19676. The Manufacture of Aluminum. W. S. Sample (M W-Began Feb. 2—2 parts to date—30 cts. each).

19779. Calculation of Fuel Charges for the Iron Blast Furnace. A. P. Bjerregaard (Ir Age-Began Feb. 15—2 parts to date—15 cts. each).

20022. Variations in the Milling of Gold Ores.—Bendigo, Australia (E M J-Began Feb. 24—Ended March 3—2 parts—15 cts. each).

MILITARY ENGINEERING.

*19689. The Rolling of Battleships of the Royal Sovereign Class (Eng L-Feb. 2.) 1700 w.

*19694. Engineers for the Navy. Editorial (Eng L-Feb. 2.) 1600 w.

19739. Making Breech-loading Rifled Mortars. Ill. (A M-Feb. 15.) 4500 w.

19742. Fulton's Torpedo. Ill. (Sc A-Feb. 17.) 1500 w.

19776. The Old Kearsarge Wrecked. (Reprinted from N. Y. Tribune.) (Sea-Feb. 15.) 1400 w.

†19836. The British Navy (W R-Feb.) 2800 w.

†19992. The Outlook for War in Europe. Archibald Forbes (N A R-March.) 4400 w.

†19996. A Naval Union with Great Britain.—A Reply to Mr. Andrew Carnegie. G. S. Clarke (N A R-March.) 5700 w.

20016. The Naval Nightmare. Fred Woodrow (A S-Feb. 24.) 700 w.

*20180. The Catastrophe on Board the Brandenburg. Ill. Editorial (Eng L-Feb. 23.) 1600 w.

†20208. Should the Fixed Coast Defenses of the United States Be Transferred to the Navy? Peter C. Hains (J M S I-March.) 11300 w.

†20209. Suggestions for Consideration, Relative to the Quartermaster's Department, United States Army. J. G. C. Lee (J M S I-March.) 11300 w.

†20211. The Management of a Post Hospital. John Van R. Hoff (J M S I-March.) 7500 w.

†20212. The Provost Marshal. G. S. Carpenter (J M S I-March.) 7300 w.

†20213. Rifle Practice in Its Relation to Eye-Strain. Ill. John M. Banister (J M S I-March.) 6000 w.

*20218. "Admiralty Practice." Editorial (E-Feb. 23.) 2000 w.

*20220. Why We Need a Navy. Editorial (E-Feb. 23.) 3000 w.

†20251. The United States Triple-Screw Protected Cruiser "Columbia." Ill. Thomas F. Carter (J A N E-Feb.) 10800 w.

†20252. Loss of H. M. S. Victoria (J A N E-Feb.) 27000 w.

†20253. The Contract Trial of the United States Steamship Marblehead. Ill. Clarence A. Carr (J A N E-Feb.) 17000 w.

20293. The Cipher Code.—Reprint from N. Y. Sun (ScA S-March 10.) 2000 w.

20294. American Men for the Navy. F. M. Bennett (ScA S-March 10.) 1800 w.

20332. The Torpedo Boat "Cushing." Ill. (I Age-March.) 1200 w.

Serials.

16960. Remarks Upon the Organization of the Armies of Europe. J. J. O'Connell (J M S I-Began Nov.—3 parts to date—45 cts. each).

20068. The Future of Naval Warfare. H. Middleton (Inv-Began Feb. 17—2 parts to date—30 cts. each).

20214. A General Review of Existing Artillery. Gaston Moch (J M S I-Began March—1 part to date—45 cts).

MINING.

19632. Tariff Schedule on Coal. William Lamb (M R-Feb. 9.) 2800 w.

19641. Historical Notes on Stoping Ground. Edward Halse (E M J-Feb. 10.) 1100 w.

19642. The Air Compressor Plant at the Nottingham Colliery, Pennsylvania. Ill. (E M J-Feb. 10.) 1100 w.

19643. The Wellston Coal District in Ohio J. A. Ede (E M J-Feb. 10.) 1200 w.

*19662. Precious Stones (N-Feb. 1.) 1000 w.

*19663. Mining in California.—Report of the State Mineralogist (Min W-Feb. 3.) 1800 w.

*19678. The Gelatine Explosives. P. Gerald Sanford (C G-Feb. 2.) 2700 w.

*19679. The Coal and Iron Industries in Saone-et-Loire (C G-Feb. 2.) 2500 w.

*19680. Economic Value of Victorian Coal (C G-Feb. 2.) 1800 w.

*19716. Arbitration in the Coal Trade (I C T-Feb. 2.) 2800 w.

19761. Notes on the (White) Mica Deposits and Mines of the Saguenay Region. J. Obalski (C Eng-Feb.) 1400 w.

19769 Needed Changes in Mining Methods. W. S. Chapman (M S P-Feb. 10.) 1500 w.

19775. Electricity in Mining. F. O. Blackwell in The Black Diamond. (Min R-Feb. 8.) 2000 w.

19789. The South's Gold Fields. I. J. J. Newman. II. Richard Eames, Jr. (M R-Feb. 16.) 4000 w.

19808. Gold and Silver Mining in the Southern States. Stuart W. Cramer (E M J-Feb. 17.) 1200 w.

†19834. The Coal Question and the Nationalization of Mines. Hugh H. L. Bellot (W R-Feb) 4200 w.

*19844. The Coal Discovery at Dover. (C G-Feb. 9.) 900 w.

*19846. New Central Station for Compressed Air at the Blanzy Colliery. (Abstract of papers by M. de Boisset and M. Laurens.) (C G–Feb. 9.) 4800 w.

*19886. Risks in Quarrying. (A L–Feb. 9.) 2500 w.

*19917. The Murchison Goldfield. (A M S–Jan. 6.) 2800 w.

*19918. Charters Towers Goldfield. (A M S–Jan. 6.) 1200 w.

*19920. The Coolgardie Goldfield. (A M S –Jan. 13.) 3700 w.

*19923. Remarks on the Thames Goldfield. Thomas White (A M S–Jan. 20.) 1200 w.

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*19937. Miners' Homes in the Mojave Desert. Ill. John R. Spears (Ch–March.) 2000 w.

19965. Pumping Coal to Market. (E N–Feb. 22.) 2500 w.

19967. A Gravity System for Handling Coal. (Abstract.) Tyler Calhoun (E N–Feb. 22.) 550 w.

*19987. Aboriginal Stone Quarries. W. H. Holmes in Science. (S–Feb.) 3500 w.

20019. The Mining District of Ocampo, Mexico. H. O. Horsfall (E M J–Feb. 24.) 1800 w.

20020. The Accident at the Gaylord Coal Mine (E M J–Feb. 24.) 700 w.

20021. The Mayflower Mine. California. Ill. (E M J–Feb. 24.) 900 w.

20031. Surface and Deep Mining. Taylor D. McLeod (M S P–Feb. 17.) 1200 w.

*20074. The Working of Open Quarries. Editorial (I S C–Feb. 16.) 1400 w.

*20079. The Working and Preparation of Coal in the Pennsylvania Mines. M. Leproux (C G–Feb. 16.) 4200 w.

*20081. Geology of the West Yorkshire Coalfield. (Abstract.) Arnold Lupton (C G–Feb. 16.) 1500 w.

20123. A Reply to W. S. Chapman's Article —"Needed Changes in Mining Methods." Samuel Butler (M S P–Feb. 24.) 1200 w.

20124. Auriferous Veins of Meadow Lake, California. Waldemar Lindgren (M S P–Feb. 24.) 1500 w.

20127. Gold in Georgia. George Huntington Clark (M R–March 2.) 2600 w.

20131. Draining a Flooded Mine; and the Permeability of Strata to Air. Beverley S. Randolph (E N–March 1.) 1000 w.

20149. The Cordite Case in England. (E M J–March 3.) 700 w.

20201. The American Miner in Cuba. (Min R–Feb. 22.) 600 w.

*20222. Method of Working at the Blanzy Collieries. M. Mather (C G–Feb. 23.) 5300 w.

*20225. Mechanical Rock Drilling with Compressed Air and Water Injection. (Extract.) M. J. Druge (C G–Feb. 23.) 1000 w.

*20226. Chokedamp Poisoning. W. Ernest Thomson (C G–Feb. 23.) 2500 w.

*20227. Coaldust in Mines. (C G–Feb. 23.) 2000 w.

*20228. Spontaneous Combustion in Coal Mines. (Abstract.) W. S. Gresley (C G–Feb. 23.) 1000 w.

*20233. The Coal-owners' Manifesto. (I S C–Feb. 23.) 1500 w.

†20257. The Leasing System in Colorado. (Sc Q–Sept. and Dec.) 4200 w.

†20260. The Importance of Transportation as a Factor in Cheap Mining. Ill. Percy Williams. (Sc Q–Sept. and Dec.) 2500 w.

†20262. The Michigan Mining Trip. I. General Review of the Trip. Horace H. Atkins. II. Notes on Mining in the Lake Superior Region. J. A. Parra (Sc Q–Sept. and Dec.) 6000 w.

20271. The Mesabi Iron Range. E. P. Jennings (Sc–Feb. 9.) 900 w.

20272. Petroleum in Southern California. S. F. Peckham (Sc–Feb. 9.) 1900 w.

*20280. The Red Point Drift Gravel Mine, with Discussion. Ill. Charles F. Hoffman (I S F–March.) 6000 w.

†20299. The Cerro de Pasco Mining Industry. Otto F. Pfordte (Tr A M E–Feb.) 3500 w.

†20300. The Franklinite Deposits of Mine Hill, Sussex County, New Jersey. Ill. Frank L. Nason (Tr A M E–Feb.) 2600 w.

†20306. Mine Explosions Generated by Grahamite-Dust. Ill. William Glenn (Tr A. M E–Feb.) 4000 w.

20325. Copper Reported in Northwestern Arkansas. W. A. Webber (M R–March 9.) 900 w.

20327. Are the Coal Operators Ignoramuses?—The Facts About Nova Scotia Coal. M Erskine Miller (M R–March 9.) 2500 w.

20328. Dredge for River Mining. Ill. (M S P–March 3.) 700 w.

20330. Quartz Belt of Butte County.—Abridged from Article in Oroville Register (M S P–March 3.) 1200 w.

20341. Ontario Mines in 1893 (E M J–March 10.) 1300 w.

20344. The Amy and Silversmith Case, with Editorial (E M J–March 10.) 3000 w.

20354. Mines for Idle Men (Min R–March 1.) 700 w.

Serials.

17458. The Northumberland Coalfield. M. E. (C G–Began Nov. 10—6 parts to date—30 cts. each).

18580. The Durham Coalfield. Ill. M. E. (C G–Began Dec. 22—6 parts to date—30 cts. each).

18640. Hydraulic Mining. Ill. Henry De Groot (M S P–Began Dec. 30—Ended Feb. 24 —8 parts—15 cts. each).

19079. Talks on Quarrying. Edward H. Williams, Jr. (S–Began Jan.—2 parts to date—30 cts. each).

19682. The Sinking and Equipment of Shafts. Ill. (E–Began Feb. 2—2 parts to date —30 cts. each).

19919. North Queensland Goldfield (A M S –Began Jan. 6—2 parts to date—30 cts. each).

20223. The Cumberland Coalfield. M. E. (C G–Began Feb. 23—1 part to date—30 cts).

RAILROADING.

*19614. South American Railroad Development. Courtenay De Kalb (E Mag–April.) 4000 w.

*19618. Transportation by Wire-Rope Tramways. Ill. William Hewitt (E Mag–April.) 4000 w.

19624. Wages on the Union Pacific. Editorial (R A–Feb. 9.) 1300 w.

19625. Railways in Sweden. (Extract.) V. Klemming and W. Wahren (R A–Feb. 9.) 1400 w.

*19683. Great Western Train Services (E–Feb. 2.) 3000 w.

*19714. Glasgow and Cathcart Circular Railway (R P L–Feb. 1.) 3000 w.

19741. The Boynton Bicycle Electric Railway. Ill. (Sc A–Feb. 17.) 1200 w.

†19752. Permanent Way Notes (I E–Jan. 13.) 1000 w.

19754. Locomotive Counterbalancing. Ill. Charles Seymour (R G–Feb. 16 4500 w.

19756. The Burlington Relief Department, with Editorial (R G–Feb. 16.) 2200 w.

19757. The Union Pacific Injunction Against Strikes (R G–Feb. 16.) 1200 w.

19758. A Railroad from Cucuta to Tamalameque. Map. J. T. Ford (R G–Feb 16.) 1700 w.

19764. Distant Signals at Grade Crossings. Editorial (E N–Feb. 15.) 1600 w.

19765. New Locomotives for the New York Elevated Railways (E N–Feb. 15.) 700 w.

19766. The Use and Abuse of the Distant Signal at Grade Crossings. Charles Hansel (E N–Feb. 15.) 1400 w.

19773. Comparative Weight of American and Foreign Passenger Equipment (R C J–Feb.) 900 w.

*19790. Knoxville's Suspended Railway. Ill. (S R R–Feb. 15.) 600 w.

*19792. By Cable to the Clouds.—Up the Staneerhorn. Ill. (S R R–Feb. 15.) 650 w.

*19793. A Few Facts on Fenders. Ill. (S R R–Feb. 15.) 1000 w.

*19794. Brakes on Electric Roads (S R R–Feb. 15.) 1500 w.

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*19796. Street Railway Labor in Ohio and Missouri (S R R–Feb. 15.) 600 w.

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19858. The Relation of Transportation to the Milling Interests. A. J. Vanlandingham (R R–Feb. 10.) 1700 w.

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19860. Salaries of Station Agents. James Menzies (R R–Feb. 10.) 1800 w.

*19865. Railway Companies as Dock Owners (Tr–Feb. 9.) 1000 w.

*19870. Tramways in the United Kingdom (E–Feb. 9.) 1100 w.

*19881. The Heilmann Electric Locomotive. Ill. (Eng L–Feb. 9.) 4000 w.

†19894. How Shall We Operate an Electric Railway Extending One Hundred Miles from the Power Station? H. Ward Leonard (T A I E E–Feb.) 1800 w.

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19926. Electric Switches for Trolley Lines. Editorial (E R N Y–Feb. 21.) 400 w.

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*19990. The Cable Street-Railway. Ill. Philip G. Hubert, Jr. (Sc M–March.) 4400 w.

*19999. Recent Railroad Failures and Their Lessons. Simon Sterne (F–March.) 9000 w.

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20029. Some Early Locomotives. (Abstract from Cassier's Magazine.) J. C. Trautwine, Jr. (M G–Feb. 24.) 900 w.

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20035. The Advisability of Permitting Electric Lines to Cross Railways at Grade.—From report of Railroad Commissioners of Connecticut (R A–Feb. 23.) 1200 w.

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20097. The Development of Electric Traction. Ill. Charles Hewitt (E W–March 3.) 1250 w.

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20113. Lyon Brook Bridge, New York, Ontario and Western (R G–March 2.) 900 w.

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†20121. Irish Railways. G. V. Martyn (I E–Jan 27.) 1800 w.

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†20172. The Importance of Complete Metallic Circuit for Electric Railways. J. H. Vail (S R J–March.) 4000 w.

*20175. The Draft Electric Traction Regulations.—Suggested Alterations (El–Feb. 23.) 6000 w.

*20181. Modern British Locomotives. Editorial (Eng L–Feb. 23.) 1500 w.

*20183. Duplex Compound Engines in Swiss Mountain Roads. Ill. Henry Gretener (L E–March.) 800 w.

*20184. Improving the Valve-Motion of Locomotives (L E–March.) 1400 w.

*20187. Some Brains in Wheel Making. Ill. Camille Mazeaux (L E–March.) 2000 w.

20190. The Need of Pooling. E. W. Meddaugh (R A–March 2.) 1400 w.

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*20199. The Cowlairs Works of the North British Railway. Ill. A. E. Lockyer (R W–Feb.) 3000 w.

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20269. Maximum Speed of Locomotives.—Some Interesting Facts and Figures on the Subject (E R N Y–March 7.) 800 w.

20291. A Private Palace Car. (Reprint from the Philadelphia Times.) (Sc A–March 10.) 1200 w.

†20308. Navigation of Railroads. Solomon Schindler (A–March.) 2500 w.

20316. Recent Types of Street Car Fenders. Ill. (E N–March 8.) 1800 w.

20317. Safety Fenders and Improved Brakes on Street Railways. Editorial (E N–March 8.) 1600 w.

20321. Steam Distribution for High Speed Locomotives (R G–March 9.) 4300 w.

20322. The Distribution of Weight on Driving Wheels. Editorial (R G–March 9.) 1600 w.

20323. The Pennsylvania Railroad Report (R G–March 9.) 1300 w.

20333. A Novel System Proposed for Rapid Transit from Chicago to New York. Ill. (I Age–March.) 800 w.

Serials.

12001. Rails on the Creep. Ill. A. Ewbank (I E–Began March 11, 1893—40 parts to date—45 cts. each).

15496. Railroad Coppersmithing. John Fuller, Sr. (L E–Began Sept.—7 parts to date—30 cts. each).

17464. Vancouver to Chicago. Ill. Killingworth Hedges (I & I–Began Nov. 10—2 parts to date—30 cts. each).

17826. Evolution of the Air Brake. Ill. Paul Synnesvedt (R E M–Began Dec.—4 parts to date—15 cts. each).

18225. Experiences of a Superintendent. C. P. Young (S R R–Began Dec.—3 parts to date—30 cts. each).

18549. The Intrinsic Value of Street Railway Investments. Edward E. Higgins (S R J–Began Jan.—3 parts to date—45 cts. each).

18711. Electric Railway Motors: Their Construction and Operation. Ill. Nelson W. Perry (S R G–Began Jan. 6—9 parts to date—15 cts. each).

18891. The Railway Mania. G. A. Sekon (R P L–Began Jan. 1—Ended Feb. 1—2 parts—30 cts. each).

18957. Ventilation of Passenger Cars. James F. Hobart (R C J–Began Jan.—2 parts to date—15 cts. each).

18968. Moving Houses over Railway Tracks (S R R–Began Jan.—2 parts to date—30 cts. each).

19251. Around the World, to China, and Home. E. J. Lewis (L E–Began Feb.—Ended March—2 parts—30 cts. each),

19306. The Third Avenue Cable Railway, New York City (E N–Began Feb. 1—3 parts to date—15 cts. each).

19340. The Transformation of Baltimore. Ill. (S R J–Began Feb.—2 parts to date—45 cts. each).

19505. Notes on Some French and Italian Railways. J. Pearson Pattinson (R W–Began Jan.—2 parts to date—30 cts. each).

19527. Electrolytic Effects in Street Railway

Return Circuits ; Their Cause and Prevention. W. Nelson Smith (S R G–Began Feb. 3—Ended Feb. 17—3 parts—15 cts. each).

20112. Vestibules, Platform Canopies and Hoods. Ill. (R G–Began March 2—2 parts to date—15 cts. each).

20206. The Electric Tramway at Remscheid. Ill. Julius Maier (E L–Began Feb. 23—1 part to date—30 cts).

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19653. The Modern Rain-Bath. William Paul Gerhard (A A–Feb. 10.) 4400 w.

19767. Area Needed for Sewage Disposal by Irrigation. George E. Waring, Jr. (E N–Feb. 15.) 2500 w.

19807. Flushing of the Tiber Sewer Outlet, Washington, D. C. Ill. Charles F. Powell (E R–Feb. 17.) 700 w.

*19861. Street Gullies (I & I–Feb. 9.) 3600 w.

*19867. The Purification of Sewage by Microbes. Editorial (E–Feb. 9.) 2000 w.

19957. Plumbing Instruction at the Pratt Institute. Ill. (Met W–Feb. 24.) 1800 w.

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20013. Sewage Disposal, Framingham and Marlborough, Mass. Ill. (E R–Feb. 24.) 1400 w.

20155. Filtration of Water and Sewage. (Abstract.) Hiram F. Mills (A & B–March 3.) 1650 w.

Serials.

5358. Sewage Purification in America. Ill. (E N–Began July 14, 1892—39 parts to date—15 cts. each).

10425. A Healthy Home. Francis Vacher (S R–Began Feb. 1, 1893—26 parts to date—30 cts. each).

14839. Water Purification in America. Ill. (E N–Began Aug. 3—8 parts to date—15 cts. each).

18870. Humidity and Ventilation. Joseph Masinette (A Ar–Began Jan. 13—2 parts to date—15 cts. each).

19813. American Plumbing (D E–Began Feb—1 part to date—30 cents).

20014. Plumbing in the Metropolitan Building. Ill. (E R–Began Feb. 24—1 part to date—15 cts).

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19628. Petroleum vs. Coal (M G–Feb. 10.) 1000 w.

19631. About Boilers—To Figure the Strength of a Riveted Joint. Ill. (B J C–Feb. 10.) 2000 w.

*19637. Economic Value of Steam-Pressure Records. Jarvis B. Edson (E M–Feb.) 3700 w.

*19685. Fact and Fiction in Boiler Explosions (E–Feb. 2.) 1500 w.

*19710. Triple Expansion Engines. Joseph Butterworth (P Eng–Feb. 2.) 2500 w.

19737. Concerning Boilers. W. H. Wakeman (A M–Feb. 15.) 1100 w.

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*19799. Maximum Contemporary Economy of the Multiple-Expansion Steam Engine. R. H. Thurston (S J E–Feb.) 5000 w.

19812. The Generation of Steam from the Waste Heat and Gases of Coke Ovens. Ill. Erskine Ramsay (A M & I W–Feb. 16.) 5500 w.

*19814. Bends and Pipe Bending. Leicester Allen (D E–Feb.) 850 w.

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*19843. Some Advantages in Using Sized Clean Coal. Walter J. May (C G–Feb. 9.) 1500 w.

19856. An Interesting Boiler Explosion at Towanda, Pa. Ill. (S V–Feb. 15.) 550 w.

*19875. Economical Steam Compression. J. Burkitt Webb (M W–Feb. 9.) 600 w.

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19900. Economy in Steam Generation. B. J. Arnold (E E–Feb.) 1600 w.

19969. Incrustation in Boilers—The Danger from It and the Proper Way to Prevent It (B J C–Feb. 24.) 1850 w.

19970. Cylinder Condensation—Its Relation to Steam Engine Economy (B J C–Feb. 24.) 1800 w.

*19985. The Country Engineer and His Indicator. Ill. F. Riddell (S–Feb.) 1500 w.

*20119. Pump Valves. W. E. Lilley (A E R J–March.) 1800 w.

20156. Concerning the Slide Valve. George C. Shepard (M R C–March 1.) 1500 w.

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20158. Guides and Crossheads—The Proper Form and Methods of Oiling (B J C–March 3.) 700 w.

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20161. Feed Water for Steam Boilers (M G–March 3.) 1600 w.

*20182. The Elements of Boiler-Making. Ill. C. E. Furness (L E–March.) 1800 w.

*20229. Externally-Fired Boilers (P Eng–Feb. 23.) 2000 w.

†20255. The New Thornycroft Boiler. Ill. (J A N E–Feb.) 11500 w.

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20288. Chimneys. William Barnet Le Van (A M–March 8) 1000 w.

20355. Building an Engine Foundation.—What to Use and how to Do It. Ill. (B J C–March 10.) 1600 w.

20356. Oils and Lubrication.—The Different Kinds and Uses (B J C–March 10.) 1700 w.

Serials.

11138. Notes on the Steam Injector. Ill. Strickland L. Kneass (E M–Began March, 1893—12 parts to date—30 cts. each).

13033. Practical Hints to Boilermakers and Templaters. Ill. (M W–Began May 12—6 parts to date—30 cts. each).

16756. Theory of Steam Engine Governors. J .Begtrup (A M–Began Oct. 19—4 parts to date—15 cts. each).

18986. Boiler Calculations. James F. Hobart (S M–Began Jan. 15—3 parts to date—15 cts. each).

19042. Water-Tube Boilers. Ill. (Eng L–Began Jan. 12—Ended Feb. 16—6 parts—30 cts. each).

19639. High Speed Station Engines. John Radinger (E M–Began Feb.—1 part to date—30 cts).

19675. On Rotatory and Reaction Engines. Ill. Alexander Morton (M W–Began Feb. 2—Ended Feb. 9—2 parts—30 cts. each).

19709. The Indicator and Its Diagrams. Ill. Charles Day (P Eng–Began Feb. 2—2 parts to date—30 cts each).

19755. Analysis of Boiler Tests by Bryan Donkin and Kennedy. Ill. (R G–Began Feb. 16—Ended March 2—2 parts—15 cts. each).

19882. Trial of McPhail and Simpson's Superheater. Ill. J. F. L. Crosland (Eng L–Began Feb. 9—Ended Feb. 16—2 parts—30 cts. each).

TELEPHONY AND TELEGRAPHY.

19629. Improvements in Telephone Exchange Service at St. Louis. Ill. (W E–Feb. 10.) 1400 w.

19630. The Telephone Situation (W E–Feb. 10.) 3000 w.

19671. The New Telephone Exchange at Paris. Ill. (E R N Y–Feb. 14.) 1700 w.

19672. Some Telephonic Discussion. Julian A. Moses (E R N Y–Feb. 14.) 1200 w.

*19698. French Cable Enterprise. Map (El–Feb. 2.) 1300 w.

*19706. A Photo-Telegraph. H. C. Johnson (E L–Feb. 2.) 1100 w.

19734. A Contribution to the Theory of Telephony. A. E. Kennelly (E W–Feb. 17.) 1800 w.

†19910. On the Excursion of the Diaphragm of a Telephone Receiver. Charles R. Cross and Henry M. Phillips (T Q–Oct.) 1200 w.

19928. How to Make a Telephone Call. Ill. (ScA–Feb. 24.) 2000 w.

19979. Projected Ocean Cables (W E–Feb. 24.) 850 w.

*20049. Telegraphic Communication between England and India: Its Present Condition and Future Development, with Discussion. E. O. Walker (J S A–Feb. 16.) 1100 w.

20092. A Review of the Progress of Telegraphy During the Past Quarter of a Century. William Maver, Jr. (E W–March 3.) 1000 w.

20093. The Birth and Growth of Telephony. Thomas D. Lockwood (E W–March 3.) 1400 w.

*20174. The New Telegraph Cable in the St. Gotthard Tunnel (El–Feb. 23.) 2200 w.

*20178. Electric Signalling Without Wires, With Discussion. W. H. Preece (J S A–Feb. 23.) 5000 w.

*20219. Inductive Telegraphy. Editorial (E–Feb. 23.) 1400 w.

*20250. The Telegraphic Link between England and India (I & I–Feb. 23.) 1600 w.

Serials.

18628. The Electro-Magnet; or, Joseph Henry's Place in the History of the Electro-Magnetic Telegraph. Ill. Mary A. Henry (E E N Y–Began Jan. 3—7 parts to date—15 cts. each).

18876. The Telephone Patent Situation (E E N Y–Began Jan. 17—5 parts to date—15 cts. each).

20069. Visual Telegraphy.—A Review of the Work in this Field (E N Y–Began Feb. 28—1 part to date—15 cts).

MISCELLANEOUS.

19447. On the Problem of Aerial Navigation. (Reprint from Aeronautics.) C. W. Hastings (Eng–Feb. 3.) 1800 w.

†19451. Views of Rubber Men on Rubber-Tree Culture (I R W–Jan. 15.) 2200 w.

†19453. Causes of Decomposition in India-Rubber Proofed Goods. Percy Carter Bell (I R W–Jan. 15.) 1000 w.

*19466. The Position and Prospects of Aerial Navigation (E Rev–Jan. 20.) 1400 w.

†19472. The Dotsero Volcano. Ill. Arthur Lakes (Sc Q–Jan.) 3000 w.

19478. The Burned Testing Laboratory at Purdue University. Ill. (R R–Feb. 3.) 500 w.

*19486. The Scientific Uses of Liquid Air.—Report of Lecture by Prof. Dewar (C G–Jan. 26.) 1500 w.

*19511. A Lesson in Eastern Enterprise and Progress We Can Well Afford to Note (Inv–Jan. 27.) 1500 w.

*19519. Transporting Buildings. Ill. (Eng L–Jan. 26.) 1100 w.

†19532. The Relation of the Land Question to Other Reforms. J. Bellangee (A–Feb.) 3300 w.

†19533. Honest and Dishonest Money. John Davis (A–Feb.) 4200 w.

19545. How Gold Is Shipped (Min R–Feb. 1.) 1500 w.

*19616. The Beet-Sugar Industry in the United States. Ill. Harvey W. Wiley (E Mag-April.) 3000 w.

*19621. The Growing Influence of the Engineer. J. F. Holloway (E Mag-April.) 3000 w.

*19622. The Outlook for an Improvement in Business. J. Edward Simmons (E Mag-April) 2500 w.

*19665. Fossil Wood. A. S. Wilson (K-Feb. 1.) 2900 w.

*19666. Viscosimetry. Ill. (I & I-Feb. 2.) 2200 w.

*19686. The Antwerp Exhibition. Ill. (E-Feb. 2.) 2000 w.

*19688. The Public Life of Works of Art in Greece (A L-Feb. 2.) 2800 w.

†19745. Fabian Economics. W. H. Mallock (F R-Feb.). 10500 w.

†19747. The Political Future of "Labor." T. R. Threlfall (N C-Feb.) 7200 w.

*19827. Some Industrial Achievements and Lessons of the Past Year (Inv-Feb. 10.) 2200 w.

†19835. Cardinal Vaughan and the Social Question. W. R. Sullivan (W R-Feb.) 3500 w.

19839. The Art of Book and Newspaper Illustration. (Extracts.) Henry Blackburn (A A-Feb. 17.) 4500 w.

19857. A Comparison of the Leading Patent Systems. F. W. Barker (S V-Feb. 15.) 900 w.

†19909. The Educational Process of Training an Engineer. Gaetano Lanza (T Q-Oct.) 5000 w.

†19912. The Technical School and the University. Francis A. Walker (T Q-Oct.) 2600 w.

†19913. The Origin of Parallel and Intersecting Joints. W. O. Crosby (T Q-Oct.) 2500 w.

*19931. The City of Washington. Ill. (E I-Feb.) 2500 w.

*19936. A Study of Anarchists and Their Theories in Europe. Paul Desjardins (Ch-March.) 2700 w.

*19997. An Income Tax : Is It Desirable? David A. Wells (F-March.) 6000 w.

*19998. An Income Tax: Reasons in Its Favor. U. S. Hall (F-March.) 2000 w.

*20000. Colonization as a Remedy for City Poverty. F. G. Peabody (F-March.) 4800 w.

*20001. Current Plans for Reforming Society. I.—The Programme of the Nationalists. Edward Bellamy. II.—The Absurd Effort to Make the World Over. W. G. Sumner (F-March.) 9500 w.

†20017. A German Hard-Rubber Factory and Its Owner—Dr. H. Traun's Harburg Rubber Co. (I R W-Feb. 15.) 2100 w.

†20018. No Results from Rubber Culture Up to Date. Herman Reimers (I R W-Feb. 15.) 1000 w.

*20036. Flying Machinery. Editorial (M-Feb. 15.) 1100 w.

*20046. Discoveries and Inventions of the Latter End of the Nineteenth Century. Moonshine (E R L-Feb. 16.) 3300 w.

*20053. The Jardin des Plantes (A L-Feb. 16.) 2600 w.

*20065. The Johns Hopkins University, Baltimore (E-Feb. 16.) 1900 w.

20070. Concerning a Change of Policy in the Administration of the Patent Office. (Abstract.) Philip Mauro (E N Y-Feb. 28.) 1800 w.

20151. The Training of Engineers. George W. Melville (Eng-March 3.) 2300 w.

20152. Success in Industrial Management. (Abstract.) Thomas D. West (I T R-March 1.) 900 w.

*20198. The Ship Canal and the Rate Question (Tr-Feb. 23.) 1400 w.

*20216. The University of Chicago (E-Feb. 23.) 2300 w.

*20238. The Caves at Mentone (A L-Feb. 23.) 1500 w.

†20243. New Species of Crinoids and Brachiopods from the Missouri Hamilton. Ill. R. R. Rowley (A G-March.) 1000 w.

†20244. The Chemical Composition of Some of the White Limestones of Sussex County, New Jersey. Frank L. Nason (A G-March.) 1600 w.

†20245. A Bit of Iron Range History. Horace V. Winchell (A G-March.) 2800 w.

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†20303. Some Experiments for Determining the Refractoriness of Fire-Clays. Ill. H. O. Hofman and C. E. Demond (Tr A M E-Feb.) 4500 w.

†20307. The Right of Eminent Domain. Edward Osgood Brown (A-March.) 2000 w.

20343. The Calculation of the Fusibility of Clays. H. A. Wheeler (E M J-March 10.) 1200 w.

Serials.

14653. Theory vs. Practice. W. M. Patton (S-Began July—8 parts to date—30 cts. each).

16290. The Atmosphere as a Medium of Travel. Fred W. Brearey (I & I-Began Sept. 15—9 parts to date—30 cts. each).

16514. The Evolution of Artificial Light. E. L. Lomax (P A-Began Oct. 16—8 parts to date—15 cts each).

17553. Management of Men and Manufacturing Industries. Thomas D. West (Ir Age-Began Nov. 23—6 parts to date—15 cts. each).

18912. Engineering Cost Accounts (E-Began Jan. 5—Ended Feb. 23—4 parts—15 cts. each).

18930. Carnot and Modern Heat. Oliver Lodge (Eng L-Began Jan. 5—8 parts to date—30 cts. each).

19052. Notes on the Manufacture of Ropes. Ill. W. C. Popplewell (P Eng-Began Jan 12—3 parts to date—30 cts. each).

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OF THE UNITED STATES AND GREAT BRITAIN.

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THE AMERICAN PRESS.

A........Arena. *m.* $5 per year. Boston.
AA......American Architect. *w.* $6. Boston.
Aer......Aeronautics. *m.* $1. N. Y.
An A A..Annals of Am. Academy of Political and Social Science. *b-m.* $6. Philadelphia.
A An.... American Analyst. *f.* $1. New York.
A Ar.... American Artisan. *w.* $2. Chicago.
A & B....Architecture and Building. *w.* $6. N. Y.
A B D....Architect, Builder and Decorator. *m.* $2. Minneapolis.
A C J....Am. Chem. Journal. *b-m.* $4. Baltimore.
A E R J.Am. Eng. and Railroad Journal. *m.* $3. N. Y.
A G......Am. Geologist. *m.* $3.50. Minneapolis.
A G L J..Am. Gas Light Journal. *w.* $3. New York.
A H......Annals of Hygiene. *m.* $2. Phila.
A J Phar.Am. Journal of Pharmacy. *m.* $3. Phila.
A J R A..Jour. R'y. Appliances. *m.* $2. New York.
A M......American Machinist. *w.* $3. New York.
A M & I W.Am. Man. and Iron World. $4. Pittsburg.
Am S....American Shipbuilder. *w.* $2. New York.
A & N J..Army and Navy Journal. *w.* $6. New York.
A & N R..Army and Navy Register. *w.* $3. Wash'ton.
A R......Architectural Record. *q.* $1. New York.
A Rev....Architectural Review. *s-q.* $5. Boston.
A S .....Age of Steel. *w.* $3. St. Louis.
B B......Brick Builder. *m.* $2.50. Boston.
B C......Boston Commonwealth. *w.* $2.50. Boston.
B G S....Bul. Am. Geog. Soc. *q.* $5. New York.
B I S ....Bul. Am. Iron and St. Asso. *w.* $4. Phila.
B J C ...Boston Jour. of Commerce. *w.* $3. Boston.
B & W...Builder and Woodworker. *m.* $3. N. Y.
C........Compass. *m.* $1. New York.
C A......Calif. Architect. *m.* $3. San Francisco.
Can A. Canadian Architect. *m.* $2. Toronto.
C & B... Carpentry and Building. *m.* $1. New York.
C E .....Colliery Engineer. *m.* $2. Scranton, Pa.
C E N... Canadian Elec. News. *m.* $1. Toronto.
C Eng....Canadian Engineer. *m.* $1. Montreal.
Ch.......Chautauquan. *m.* $2. Meadville, Pa.
C M......Century Magazine. *m.* $4. New York.
Cos.......Cosmopolitan. *m.* $1.50. New York.
D E......Domestic Engineering. *m.* $2. Chicago.
E A......Electrical Age. *w.* $3. New York.
E E .....Electrical Engineering. *m.* $1. Chicago.
E E N Y..Electrical Engineer. *w.* $3. New York.
E I.......Electrical Industries. *m.* $1. Chicago.
Elek ....Elektron. *m.* $3. Boston.
E M......Engineering Mechanics. *m.* $2. Phila.
E Mag ...Engineering Magazine. *m.* $3. New York.
E M J....Eng. and Mining Journal. *w.* $5. N.Y.
E N......Engineering News. *w.* $5. New York.
Eng .....Engineer. *s-m.* $2. New York.
E N Y....Electricity. *w.* $2.50. New York.
E R......Engineering Record. *w.* $5. New York.
E R N Y..Electrical Review. *w.* $3. New York.
E & R ...Elec. and Railroading. *m.* $1. Boston.
E S W P...Proc. Eng. So. of W. Pa. *m.* $7. Pittsburg.
E W......Electrical World. *w.* $3. New York.
F ....Forum. *m.* $3. New York.
F D......The Foundry. *m.* $1. Detroit.
F W .....Fire and Water. *w.* $3. New York.
G & F....Garden and Forest. *w.* $4. New York.
G G M...Goldthwaite's Geograp. Mag. *m.* $2. N. Y.
G R......Good Roads. *m.* $2. New York.

I A......Inland Architect. *m.* $5. Chicago.
I Age....Inventive Age. *s-m.* $1. Washington.
Ir Age..Iron Age. *w.* $4.50. New York.
I I G.....Iron Ind. Gazette. *m.* $1.50. Buffalo.
I R W...India Rubber World. *m.* $3. New York.
I S F.....Industry. *m.* $2. San Francisco.
I T R....Iron Trade Review. *w.* $3. Cleveland.
J A... ..Journal of Architecture. *m.* $2. Phila.
J A C S..Jour. Am. Chem. So. *m.* $5. Easton.
J A E S..Jour. Assoc. Eng. Soc. *m.* $3. Chicago.
J A N E..Jour. Am. Soc. Naval Engineers. *qr.* $5. Washington.
J F I.....Jour. Franklin Institute. *m* $5. Phila
J M S I..Jour. Milit. Service In. *b-m.* $4. NewYork.
J N E W.Jour.N.E.Waterw. As. *q.* $2. New London.
J P E.....Jour. Polit. Economy. *q.* $3. Chicago.
J U S A..Jour. U. S. Artillery. *q.* $2.50. Ft. Monroe.
L E......Locomotive Engineering. *m.* $2. N. Y.
L. H. P..Light, Heat and Power. *m.* $3. Phila.
L Mag...Lippincott's Magazine. *m.* $3. Phila.
M & B...Manufacturer and Builder. *m.* $1.50. N. Y.
M & El...Mech. and Electrician. *w.* $2. St. Louis.
Met W...Metal Worker. *w.* $2. N. Y.
M G......Manufacturer's Gazette. *w.* $3. Boston.
Mill......Milling. *m.* $2. Chicago.
Min......Minerals. *m.* $1. N. Y.
Min. R...The Mining Review. *w.* $2. Denver.
M I T....Mining Industry. *w.* $3. Denver.
M N.....Mechanical News. *s-m.* $1.50. New York.
M R......Manufacturer's Record. *w.* $4. Baltimore.
M R C...Marine Review. *w.* $2. Cleveland, O.
M Rec....The Marine Record. *w.* $2. Cleveland.
M S P....Min. and Sci. Press. *w.* $3. San Francisco.
M S R....Mining and Sci. Review. *w.* $2. Denver.
N A R...North American Review. *m.* $5. N. Y.
N B .....National Builder. *m.* $3. Chicago.
N C B...National Car Builder. *m.* $2. New York.
N P R...Nat. Popular Review. *m.* $2.50. Chicago.
N W.....Nowest. Architect. *m.* $3. Minneapolis.
O P D R..Oil, Paint and Drug Reporter. *w.* $6. N.Y.
P.........Paving. *m.* $2. Indianapolis.
P A......Progressive Age. *s-m.* $3. New York.
P E C P.Proed. Engineer's Club. *q.* $2. Phila.
P S......Power-Steam. *m.* $1. N. Y.
P S M....Popular Science Monthly. *m.* $5. N. Y.
R A ....Railway Age. *w.* $4. Chicago.
R C J....Railroad Car Journal. *m.* $1. New York.
R E M....Railway Engineering and Mechanics. *m.* $1. Chicago.
R G .....Railroad Gazette. *w.* $4.20. N. Y.
R M.....Roller Mill. *m.* $2. Buffalo, N. Y.
R of R...Review of Reviews. *m.* $2.50. New York.
R R......Railway Review. *w.* $2. Chicago.
R & T...Roofer and Tinner. *m.* $1. N. Y.
R'y N....Railway News. *m.* $2. New York.
S... .....Stone. *m.* $2. Chicago.
S A......Southern Architect. *m.* $2. Atlanta.
San......Sanitarian. *m.* $4. Brooklyn.
Sc........Science. *w.* $3.50. New York.
Sc A ....Scientific American. *w.* $3. New York.
Sc A S ...Scientific Am. Supplement. *w.* $5. N. Y.
Sc M....Scribner's Magazine. *m.* $3. New York.
S E .....Stationary Engineer. *w.* $2. Chicago.
Sc Q.....Scientific Quarterly. *q.* $2. Golden, Cal.
Sea......Seaboard. *w.* $2. New York.
S Ec.....Social Economist. *m.* $2. New York.
S J E....Sibley Jour. of Eng. *m.* $2. Ithaca, N. Y.
S M.....ScientificMachinist.*s-m.*$1.50. Cleveland,O.
So L .....Sou. Lumberman. *s-m.* $2. Nashville.
S M Q....School of Mines Quarterly. $2. N. Y.
S R E N..St. R'y. Elec. News. *m.* $2. Minneapolis.
S P......Sanitary Plumber. *s-m.* $1. New York.
S R G....Street Railway Gazette. *w.* $3. Chicago.
S R J....Street Railway Journal. *m.* $4. New York.
S R N. ..Street Railway News. *w.* $3. New York.
S R R.. .Street Railway Review. *m.* $2. Chicago.
S V......Safety Valve. *m.* $1. New York.
T ....Tradesman. *s-m.* $2. Chattanooga, Tenn.
T A I E E.Trans. Am. Ins. Elec. Eng. *m.* $5. N. Y.
T C E....Trans. Am. Soc. Civil Eng. *m.* $10. N. Y.
T Q......Technology Quarterly. $3. Boston.
Tr A M E.Trans. Am. Ins. of Mining Eng. N. Y.
T W A .Trans. of the Wis. Acad. Madison.
W E.. ..Western Electrician. *w.* $3. Chicago
W G R..Water and Gas Review. *m.* $1. New York.

THE FOREIGN PRESS.

A L.....The Architect. *w.* 26*s.* London.
A M S.. Aust. Mining Standard. *w.* 30*s.* Sydney.
A P R...Aus. Pastoralists' Rev. *m.* 20*s.* Sydney.
B A.... .The British Architect. *w.* 23*s.* 8*d.* London.
C G.. ..Colliery Guardian. *w.* 27*s.* 6*d.* London.
C R......Contemporary Review. *m.* $4.50. London.
C T J....Chem. Trade Jour. *w.* 12*s.* 6*d.* Manchester.
E.........Engineering. *w.* 36*s.* London.
E E L....Electrical Engineer. *w.* 19*s.* 6*d.* London.
E G......Engineers' Gazette. *m.* 8 *s.* London.
E L.......Electricity. *w.* 7*s.* 6*d.* London
El.. .....Electrician. *w.* 24*s.* London.
EngL... Engineer. *w.* 36*s.* London.
E P......Electrical Plant. *m.* 6*s.* London.
E Rev....Engineering Review. *m.* 7*s.* London.
E R L.....Electrical Review. *w.* 21*s.* 8*d.* London.
F R......Fortnightly Review. *m.* $4.50. London.
G E M...Gas Engrs' Mag. *m.* 6*s.* 6*d.* Birmingham.
G W......Gas World. *w.* 13*s.* London.
I & I.....Industries and Iron. *w.* £1. London.
I & S.....Iron and Steel Trades' Jour. *w.* 25*s.* London.
I C B... .Carpenter and Builder. *w.* 8*s.* 8*d.* London
I TCR....Iron and Coal Review. *w.* 30*s.* 4*d.* London.
I E.......Indian Engineering. *w.* 18 Rs. Calcutta.
I Eng....Indian Engineer. *w.* 20 Rs. Calcutta.
Inv......Invention. *w.* 11*s.* London.
I S C.....The Iron, Steel and Coal Times. *w.* £1 6*s.* London.
J G L....Journal of Gas Lighting. *w.* London.
J S A....Journal of the So. of Arts. *w.* London.
K........Knowledge. *m.* 6*s.* London.
M........Machinery. *m.* 9*s.* London.
M E......Marine Engineer. *m.* 7*s.* 6*d.* London.
M E & E J.Man. Eng. and Export Jour. *m.* London.
Min W..The Mining World. *w.* 21*s.* London.
M W.....Mechanical World. *w.* 8*s.* 8*d.* London.
N....... Nature. *w.* $7. London.
N C......Nineteenth Century. *m.* $4.50 London.
P Eng...Practical Engineer. *w.* 10*s.* London.
Pl D .....Plumber and Decor. *m.* 6*s.* 6*d.* London.
R N......Railway News. London.
R P L....The Railway Press. *m.* 7*s.* London.
R R L...The Railway Review. *w.* London.
R W.....Railway World. *m.* 5*s.* London
S L......Steamship. *m* Leith, Scotland.
S R......Sanitary Record. *m.* 10*s.* London.
Tr.......Transport. *w.* £1. 5*s.* London.
W R.....Westminster Review. *m.* $4.50. London.

ARCHITECTURE.

*20358. Architectural Education for America. III The English method. R. W. Gibson. IV. An Outsider's View. Barr Ferree (E Mag-May) 3000 w.

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*21151. Indiana Building Stones. Maurice Thompson (S-April.) 1800 w.

*21152. Building Stones in Vicinity of Cincinnati, O. W. B. Ruggles (S-April.) 6000 w.

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CIVIL ENGINEERING.

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20369.—$1.50. Discussion on paper by William Murray Black—"The Improvement of Harbors on the South Atlantic Coast of the United States" (T C E–Dec.) 5000 w.

20374.—$1.50. "The Continuous Superstructure of the Memphis Bridge"—Discussion on paper by George S. Morison (T C E–Dec.) 2800 w.

20375.—$1.50. "Bridge Substructure and Foundations in Nova Scotia." Ill. Discussion on paper by Martin Murphy (T C E–Dec.) 4000 w.

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*20578. Pile Driving. (Abstract.) Henry O'Connor (G W–March 10.) 2800 w.

*20617. The Improvement of the River Clyde. Editorial (E–March 9) 900 w.

20657. Tunnels near New York City. Reprint from the N. Y. Tribune (Sc A S–March 24.) 2500 w.

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†20729. Wear and Tear of Materials on Macadamized Roads. R. C. McKennie (I Eng–Feb. 17.) 2500 w.

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20818. A New Speedway on the Banks of the Harlem River, in New York City. Ill. (Sc A–March 31.) 1500 w.

*20828. Inter-Oceanic Ship Canal Communication by the American Isthmus. (Extracts.) N. J. Manson (C A–March.) 3000 w.

20840. The Prospect of a North River Bridge. Chauncey M. Depew in N. Y. Tribune (E N–March 29.) 900 w.

20870. The Romance of the Great Canal. Ill. G. T. Ferris (Cos–April.) 3500 w.

*20893. Building Stone for Engineering Structures. (Extracts.) W. B. Ruggles (A E R J–April.) 2700 w.

*20952. The Properties of Asphalts. E. J. De Smedt (P–April.) 1500 w.

*20953. Brick Paved Streets and Roads. A. O. Jones (P–April.) 1650 w.

*21002. Landslides. Ill. David Molitor (J A E S–Jan.) 10500 w.

*21004. A New Prismatic Stadia. Ill. Robert H. Richards (J A E S–Jan.) 3500 w.

21012. The Bartissol Plan for Finishing the Panama Canal (E G–April 5.) 900 w.

21017. The Bearing Power of Piles. (E N–April 5.) 2500 w.

21118. The Van Buren Street Tunnel, Chicago. Ill. (E R–April 7.) 1500 w.

Serials.

16520. Plant and Gear Made Locally for the Kistna Bridge. Ill. F. J. E. Spring (I E–Began Sept. 9—8 parts to date—45 cts. each).

19649. Beams of Uniform Strength. William White Robertson (I E–Began Jan. 6—3 parts to date—45 cents each).

19687. Recent Breakwaters and Sea Defences in Italy. Ill. L. Luiggi (E–Began Feb. 2—Ended March 9—3 parts—30 cts. each).

20428. Walnut Street Bridge, Philadelphia, Pa. Ill. (E R–Began March 10—Ended March 24—2 parts—15 cts each).

20688. Hudson County Boulevard (E R–Began March 24—1 part to date—15 cts).

ELECTRIC LIGHTING.

20472. Polyphase Transmission, with Discussion. Ill. Charles F. Scott (E R N Y–March 14.) 3300 w.

†20556. On the Effect of Heavy Gases in the Chamber of an Incandescent Lamp. William A. Anthony (T A I E E–March.) 6800 w.

*20574. The Brightness of Light: Its Nature and Measurement. James Mark Barr and Charles E. S. Phillips (El–March 9.) 3800 w.

20655. Private Electric Light Plants. Ill. Frank C. Perkins (E W–March 24.) 1600 w.

*20722. Notes on Designing a System of Underground Electric Light Mains. John H. Rider. (E E L–March 16.) 3300 w.

*20723. Various Systems of Underground Mains and Methods of Laying Same. S. V. Clirehugh (E E L–March 16.) 4000 w.

20726. Concerning Uniformity of Electrical Apparatus. Dr. Louis Bell in Electrical Reporter (A G L J–March 26.) 1800 w.

†20742. Electricity and Light. J. E. Gore (I E–Feb. 17.) 750 w.

20791. Small Arc Lamps. Elihu Thomson (E E N Y–March 28.) 900 w.

*20826. The Buoy Lighting of the Water-Way to the World's Fair. J J Brice (Elek–Jan.) 900 w.

*20875. Comparative Value of Certain Wiring Plans and Some Wiring Pointers. E. P. Roberts (E E L–March 23.) 1000 w.

*20876. Economy of Incandescent Lamps. W. Stuart-Smith (E E L–March 23.) 1900 w.

20973. Electricity from Kerosene. H. C. Cushing, Jr. (E E N Y–April 4.) 900 w.

†21029. Central Station Lighting. Pedro G. Salom (J F I–April.) 1800 w.

21073. Exterior Decorative Lighting at the Midwinter Fair. George P. Low (E I–April.) 600 w.

21075. Electric Lighting at Rochester, Minn. Ill. (E I–April.) 1300 w.

Serials.

6709. Electric Light and Power. Ill. Arthur F. Guy (E E L–Began Sept. 9, 1892—39 parts to date—30 cts. each).

13548. Arc Lighting. E. Tremlett Carter (E R L–Began June 2—14 parts to date—30 cts. each).

19819. Some Notes on the Electric Lighting of the City of London. Ill. Major-Gen. Webber (E E L–Began Feb. 9—Ended March 9—5 parts—30 cts. each).

20045. Rules and Regulations for Electric Lighting Steamships. Ill. Rankin Kennedy (E R L–Began Feb. 16—Ended March 30—5 parts—30 cts. each).

20247. The Nottingham Municipal Electricity Works. Ill. (E E L–Began Feb. 23—Ended March 2—2 parts—30 cts. each).

21119. South Boston Electric Light Station. Ill. (E R–Began April 7—1 part to date—15 cts).

ELECTRIC MISCELLANY.

*20363. Measurement of the Electric Current. Nelson W. Perry. (E Mag–May.) 3000 w.

20480. The Difficulties and Problems of the Electric Engineer (Sc A–March 17.) 900 w.

†20555. Discussion of paper by Louis Bell—"Practical Properties of Polyphase Apparatus." (T A I E E–March.) 6000 w.

*20598. Alternating Current and the Low-Tension Distributing Net Work. E. Parry (E E L–March 9.) 3000 w.

*20599. On Parallel Working, with Special Reference to Long Lines, with Discussion. W. M. Mordey (E E L–March 9.) 7500 w.

*20609. Hydro-Electric Installation, Antwerp. Ill. (Eng L–March 9.) 1400 w.

20627. Conduit Ownership. (Abstract.) Charles H. Morse (E R N Y–March 21.) 3000 w.

20690. The Mutual Interests of Electricity and Fire Departments. George P. Low (W E–March 24.) 1400 w.

20704. Energy Lost in the Station. Edward Weston (E E–March.) 1100 w.

*20705. Some Electrical Phenomena. Ill. (E–March 16.) 2500 w.

20790. On the Probability of Identity between Specific Electrostatic Capacity and Specific Ether Density. Edwin J. Houston and A. E. Kennelly (E E N Y–March 28.) 600 w.

20793. The Disruptive Strength of Insulating Materials. M. C. Canfield and F. George Robinson (E E N Y–March 28.) 1600 w.

20815. A Modified Instrument for the Determination of the B. H. Curves of Iron. H. W. Schroeder (E W–March 31.) 350 w.

*20824. On the Electro-Magnetic Theory of Light. A. E. Dolbear (Elek–Jan.) 1100 w.

*20825. Electrical Developments in the Far West (Elek-Jan.) 1000 w.

*20884. On Cathode Rays in Gases under Atmospheric Pressure and in Extreme Vacua. G. H. Fitzgerald (E L–March 23.) 2000 w.

*20887. Testing Iron of Transformers by a Workshop Method. Clarence P. Feldmann (E L–March 23.) 1000 w.

*20906. Nicola Tesla. Dr. v. Ettingshausen (G W–March 24.) 1900 w.

*20915. Dr. D'Arsonval's Experiments in Electro-Physiology. Ill. (E R L–March 23.) 1700 w.

20980. Apparatus for Preventing Accidents in Factories (Sc A S–April 7.) 500 w.

20986. Apparatus for Taking of Alternate Current Curves. Ill. N. H. Genung (E R N Y–April 4.) 700 w.

20988. On Certain New Prefixes Proposed for Physical Unit Magnitudes. Edwin J. Houston and A. E. Kennelly (E R N Y–April 4.) 500 w.

20997. On the Applications of the Proposed Names for the Practical Magnetic Units. Edwin J. Houston and A. E. Kennelly (E W–April 7.) 900 w.

*21087. Method of Approximately Determining the Magnetic Field at any Point Inside a Circle Carrying a Current. E. C. Rimington (E R L–March 30.) 1300 w.

21142. Electrical Engineering as a Profession. R. H. Thurston (S R G–April 7.) 1700 w.

Serials.

10464. The Silver-Plating Industry. Ill. (I. & I–Began Feb. 13, 1893—16 parts to date—30 cts each).

19085. The Copper-Zinc Accumulator. Ill. Paul Schoop (E E N Y–Began Jan. 24—Ended March 14—5 parts—15 cts. each).

19541. A Brief Review of the Faraday-Maxwell-Hertzian Epoch. M. I. Pupin (E W–Began Feb. 10—3 parts to date—15 cts. each).

19932. What I Don't Know About Electricity. George Cutter (E I–Began Feb—2 parts to date—15 cts. each).

20604. The Transformation of Electric Currents. Ill. (I & I–Began March 9—1 part to date—30 cts).

20885. On Cathode Rays in Gases Under Atmospheric Pressure and in Extreme Vacua. Ill. Philipp Lenard (El–Began March 23—2 parts to date—30 cts. each).

ELECTRIC POWER.

20458. Electric Station Economics. D. C. Jackson (S R G–March 10.) 1100 w.

20498. Three-Phased Plant at Concord, N. H. Ill. (E W–March 17.) 1600 w.

20550. Arnold's Electric Carriage. Ill. (W. E–March 17.) 900 w.

*20577. Electricity as a Motive Power in Factories. Ill. (E R L–March 9.) 3500 w.

*20600. The Patin and Levavasseur Machine. Ill. (E E L–March 9) 900 w.

*20650. Horse Power in an Electric Spark. John Trowbridge (Ch–April.) 2300 w.

20652. The New Westinghouse Combined Direct and Alternating Current Generator at Rochester, N. Y. Ill. John Dennis, Jr. (E E N Y–March 21.) 1400 w.

20653. Distributing Niagara's Power Throughout New York State. Editorial (E E N Y–March 21.) 1200 w.

*20718. Economy in the Production of Power. Forée Bain (S R E N–March.) 1600 w.

20728. The Scarborough Electric Supply Station. Ill. (El–March 16.) 2200 w.

*20758. Electric Traction on Ordinary Roads. With Editorial. Ill. (I & I–March 16.) 5000 w.

20792. The New 5000 Horse-Power Water Power Plant of the Concord Land & Water Power Company, Concord, N. H. Ill. A. C. Shaw (E E N Y–March 28.) 2800 w.

20823. The Postal Telegraph Electric Plant. Ill. (E N Y–March 28.) 1700 w.

*20874. The Sheffield Electric Light and Power Station (E E L–March 23.) 2500 w.

*20898. Electrically Operated Drills. Ill. (I & I–March 23.) 1700 w.

*20914 The Electric Motor in Aeronautics. Editorial (E R L–March 23.) 700 w.

20941. Power Station of the Union Railroad Company, Providence, R. I.—A Wrought Iron Fly Wheel. Ill. (P S–April.) 2500 w.

20955. Electric Railway Motor Tests. W. Nelson Smith (S R G–April.) 2000 w.

20969. Tudor Storage Batteries in the Central Station of the Edison Electric Illuminating Co., of Boston. Ill. A. C. Shaw (E E N Y–April 4) 1500 w.

20995. Practical Hints to Engineers on the Manipulation of Dynamos and Electrical Plants. James Milne (C E N–April.) 3500 w.

20998. The Portland General Electric Plant. Ill. (E W–April 7.) 1800 w.

21000. Transformation of Alternating Currents. Charles Proteus Steinmetz (E W–April 7.) 2000 w.

21048. Power Transmission Plant in the Illinois State Penitentiary. Ill. (W E–April 7.) 800 w.

*21110. Electricity in Sawmills and Workshops—Reprint from Timber Trades Journal (C G–March 30.) 2500 w.

Serials.

9858. The Calculation of Alternating Current Motors. E. Arnold (E W–Began Jan. 21, 1893—7 parts to date—15 cts. each).

11560 Electricity as a Motive Power. Ill. Albion T. Snell (El–Began March 17, 1893—15 parts to date—30 cts. each).

18661. Alternate Current Working. Harris J. Ryan (E W–Began Jan. 6—5 parts to date—15 cts. each).

18925. Dynamo Attendants and Their Dynamos. Alfred H. Gibbings (E L–Began Jan. 5—Ended March 23—12 parts—30 cts. each).

20626. Dynamos and Motors—Direct. (Extract.) Ill. F. B. Crocker and S. S. Wheeler (E R N Y–Began March 21—Ended March 28—2 parts—15 cts. each).

GAS ENGINEERING.

*20364. Water-Gas and Coal-Gas Compared. Ill. C. J. R. Humphreys (E Mag–May.) 3000 w.

*20433. On the Conditions Determining the Efficiency of Gas and Petroleum Engines (M W–March 2.) 1000 w.

20460. Report of Committee on "The Effect of Electric Railway Return Circuits upon Gas Pipes." (A G L J–March 12.) 6400 w.

20461. The Storage and Measurement of Enriching Oils, with Discussion. Ill. W. E. McKay (A G L J–March 12.) 7500 w.

†20470. A French Regenerative Gas Furnace. Ill. Joseph Struthers (S M Q–Jan.) 1200 w.

*20486. Presidential Address of James Braddock (J G L–March 6.) 5000 w.

20500. Water Gas Apparatus Since 1889. Ill. (P A–March 15.) 5300 w.

20596. Lime Boxes for Removing CO2, with Discussion. N. W. Gifford (A G L J–March 19.) 4200 w.

20597. The Gas Industry in 1886 and 1892, with Discussion. Robert B. Taber (A G L J–March 19.) 5400 w.

20629. Gas Burners and How to Use Them Properly. Ill. (M & B–Feb.) 2000 w.

*20721. Gas Engines (G E M–March 10.) 2200 w.

20725. Notes on Gasholders in Metal Tanks with Discussion. Mr. Godinet (A G L J–March 26.) 5000 w.

*20749. Dr. Bunte on Carburetting Gas (J G L–March 13.) 3800 w.

*20770. Co operation in an United States Gasworks. George T. Thompson. (Reprint from Light, Heat and Power.) (G W–March 17.) 1000 w.

*20812. On a Certain Slackness of Gas Engineers (J G L–March 20.) 2200 w.

*20813. Gas and Electric Light. W. J. Dibdin (J G L–March 20.) 4500 w.

*20814. Water Gas for Heating and Lighting. (Abstract.) H. Strache J G L–March 20.) 2500 w.

*20847. Water Gas in Small Works. Ill. (L H P–March.) 2200 w.

*20848. New Gas Plant of the Kentucky Heating Company. V. L. Elbert (L H P–March.) 1200 w.

*20849. The Miller Zigzag Reversible System of Gas Making. Ill. (L H P–March.) 1000 w.

*20907, Comparative Value of Coal and Coke. Messrs. Jerome and Andouin (G W–March 24.) 1500 w.

*20908. Gas Explosions in Electric Light Boxes (G W–March 24.) 1400 w.

20940. Leaks, with Discussion. W. W. Prichard (A G L J–April 2.) 1800 w.

20964 Incandescent Gas Light Progress (P A–April 2.) 1300 w.

20965. Address of President Irwin Butterworth to the Members of the Ohio Gas Light Association, with Discussion (P A–April 2.) 4800 w.

20966. The Welsbach Incandescent Gas Burner for Artificial Gas. J. W. R. Cline, with Discussion (P A–April 2.) 7200 w.

20967. The Testing of Meters. W. H. Anson, with Discussion (P A–April 2.) 3800 w.

20968. Coal Tar Pitch: Its Uses and Future Market. R. Watt, with Discussion (P A–April 2.) 5000 w.

21045. The Gas Engine.—Brief Description of the Peculiarities of Different Types (B J C–April 7.) 1400 w.

*21053. The Science and Progress of Gas Combustion. (Abstract.) C. R. Bellamy (J G L–March 27.) 2800 w.

*21112. The Use of Gas Engines for Electric Lighting in Scotland (G W–March 31.) 1200 w.

*21117. Central Station Working with Gas Engines and Accumulators. Ill. (E E L–March 30.) 700 w.

Serials.

13534. The Gas Engine. Ill. (M W–Began June 2—8 parts to date—30 cts. each).

19650. The Chemical Technology of Coal Gas. Vivian B. Lewes (J G L–Began Jan. 30—7 parts to date—30 cts. each).

19815.—Gas for the Household. Paul Gerhard (D E–Began Feb. —2 parts to date—30 cts. each).

20143. The Action of Heat upon Ethylene. Vivian B. Lewes (J G L–Began Feb. 20—Ended March 6—3 parts—30 cts. each).

20417. Gas Stoves and Ventilation. Edward J. Smith (Pl D–Began March—1 part to date—30 cts).

20821. Chemical Properties of Gases. Francis C. Phillips (Sc A S–Began March 31—2 parts to date—15 cts. each).

21052. The Development of the Gasholder. A. M'I. Cleland (J G L–Began March 27—1 part to date—30 cts).

HYDRAULICS.

20382.—$1.50. Underground Sources of Water Supply.—Discussion on paper by B. Salbach (T C E–Dec.) 4000 w.

20430. The Laredo Water Tower. Ill. (E R–March 10.) 1000 w.

20437.—75 cts. "Covered Reservoir at Brookline, Mass." Ill. F. F. Forbes (J N E W–March.) 1300 w.

20438.—75 cts. I. Water Supply of Waltham. George E. Winslow. II. Basin and Well Covering of the Waltham Water-Works, with Discussion. Ill. F. P. Johnson (J N E W–March.) 6000 w.

20439.—75 cts. The Construction of Reservoir Embankments, with Discussion. Ill. Lucien A. Taylor (J N E W–March.) 9000 w.

20440.—75 cts. The Bursting of the Portland Reservoir, with Discussion. Ill. John R. Freeman (J N E W–March.) 2700 w.

*20445. The Utilization of the Nile. Ill. (Eng L–March 2.) 2700 w.

†20466. Details of Modern Water Works Construction. Ill. Wolcott C. Foster (S M Q–Jan.) 1800 w.

20482. Irrigation by the Use of Windmills. B. A. McAllester (Sc A S–March 17.) 1700 w.

20521. The Honey Lake Valley Dam, California. Ill. P. M. Norboe (E N–March 15.) 1600 w.

20572. A Talk About Hydraulics. James F. Hobart (T–March 15.) 3700 w.

20676. A Novel Iron Reservoir in Bordeaux. Ill. (E N–March 22.) 600 w.

20687. Driven Wells at Lowell, Mass. (E R–March 24.) 1600 w.

20836. Electric Corrosion of Water Pipes in Brooklyn, N. Y. (E N–March 29.) 1300 w.

20839. Failure of a Masonry Flume. Ill. (E N–March 29.) 800 w.

20861.—$1.50. Storage and Pondage of Water. Joseph P. Frizell (T C E–Jan.) 5000 w.

20862.—$1.50. Reclamation of the Potomac Flats at Washington, D. C. Ill. Peter C. Hains (T C E–Jan.) 9000 w.

*20919. The Falls of Niagara and Its Water Power. Ill. (N–March 22.) 4700 w.

20937. The Atlanta, Ga., Water Works. Ill. (E R–March 31.) 900 w.

*21003. Water Supplies. Wynkoop Kiersted (J A E S–Jan.) 4500 w.

21016. Geyelin-Jouval Turbines in Plant of the Niagara Falls Paper Co. Ill. Emil Geyelin (E N–April 5.) 1350 w.

21018. The Peoria Stand-Pipe Failure (E N–April 5.) 3300 w.

*21054. The Artesian Well of the Commissioners of Sewers of the City of London (J G L–March 27.) 4000 w.

21056. Collapse of a Stand Pipe at Peoria. Ill. (F W–April 7.) 2500 w.

21057. The Capital City Water Co. Case. Fred Crosby (F W–April 7.) 2800 w.

Serials.

18676. The Pumping Engine: Its Many Points, Faults and Peculiarities. Ill. Ernest W. Naylor (F W–Began Jan. 6—11 parts to date—15 cts. each).

18801. Discharge of Sluices and Weirs under Varying Heads. Ill. G. C. Maconchy (I E–Began Dec. 9—6 parts to date—45 cts. each).

20126. The Water Supplies in the Arid Regions. J. W. Powell (M S P–Began Feb. 24—3 parts to date—15 cts. each).

20808. Ahmedabad Water-Works Report. Ill. (I E–Began Feb. 24—2 parts to date—45 cts. each).

21015. Stand-Pipe Accidents and Failures. William D. Pence (E N–Began April 5—1 part to date—15 cts).

21021. The Missouri River. O. B. Gunn (R G–Began April 6—1 part to date—15 cts).

INDUSTRIAL CHEMISTRY.

*20571. Refrigerating Apparatus, with Discussion. Ill. Carl Linde (J S A–March 9) 6000 w.

†21025. The River, Well and Spring Waters of McKeesport, Pa., and Vicinity—with Discussion (E S W P–Jan.) 2000 w.

21095. The Reduction of Aluminum as a Scientific Problem. Alfred H. Bucherer (E M J–April 7.) 2700 w.

Serials.

15176. The Chemical and Physical Examination of Portland Cement. Ill. Thomas B. Stillman (J A C S–Began April, 1893—2 parts to date—45 cts. each).

17576. Theoretical and Practical Ammonia Refrigeration. Iltyd I. Redwood (Eng–Began Nov. 25—10 parts to date—15 cts. each).

INDUSTRIAL SOCIOLOGY.

*20446. Some Labor Questions. Editorial (Eng L–March 2.) 1600 w.

†20478. The Impending Revolution. Goldwin Smith (N C–March.) 6500 w.

20528. Brothers in Distress. A. B. Salom (I I G–March.) 1200 w.

†20532. The Rate of Profits under the Law of Labor Value. Isaac A. Hourwich (J P E–March.) 6000 w.

†20537. Work for the Workless. Arthur Withy (W R–March.) 4000 w.

†20635. Trusts Their Own Corrective. George A. Rich (P S M–April.) 1800 w.

†20640. The Unemployed. Editorial (P S M–April.) 2000 w.

20701.—$1. The Relation of Taxation to Monopolies. Emory R. Johnson (An A A–March.) 8500 w.

20702.—$1. I. The Farmers Movement. C. S. Walker. II. The Grange and the Co-operative Enterprises in New England. Florence J. Foster (An A A–March.) 8500 w.

*20708. Employers and Employed. Editorial (E–March 16.) 1100 w.

*20949. The Economy of High Wages. (Abstract.) George Gunton (S Ec–April.) 2200 w.

*21105. The Royal Commission on Labor. Editorial (I & I–March 30.) 900 w.

*21120. The Panic of Labor. Editorial (N B–April.) 1300 w.

21144. Some History in Figures. Editorial (A S–April 7.) 650 w.

LANDSCAPE ENGINEERING.

Serials.

19346. Public Squares. Ill. T. M. Newton (A A–Began Feb. 3—Ended March 24—5 parts—15 cts. each).

MARINE ENGINEERING

*20365. The Kite as a Life-Saver at Sea. Ill. J. Woodbridge Davis (E Mag–May.) 3000 w.

*20427. The Principal Harbor at Natal. Ill. (Tr–March 2.) 3000 w.

*20455. The "Baird-Thompson" Improved System of Ship Ventilation. Ill. (S L–March.) 900 w.

20459. Some Points on Lake Navigation. J. J. Brice (M R C–March 8.) 1100 w.

20503. Details of Electric Light Buoying, as Conducted under Direction of Captain Schley (Sea–March 15.) 1200 w.

20504. The First American Steel Sailing Ship.—The Dirigo. Ill. (Am S–March 15.) 900 w.

*20589. Large Ships of Cellular Type.—A New System of Construction. Ill. William Bell (E G–March.) 4000 w.

*20590. A Launch Near the Moon (E G–March.) 1500 w.

20591. Water-Tube Boilers—With Particular Reference to Experience with Generators of the Belleville Type (M R C–March 15.) 1700 w.

*20592. The Future of American Shipping and Ship Building (Tr–March 9.) 2000 w.

*20615. Waterways in America. Editorial (E–March 9.) 1200 w.

*20696. Life Under Water. Ill. Gustav Kobbé (Sc M–April.) 4500 w.

*20697. A Winter Journey Up the Coast of Norway. Ill. Rasmus P. Anderson (Sc M–April.) 4500 w.

†20794. Our Navigation Laws. Charles H. Cramp (N A R–April.) 5200 w.

20871. Under the Cross of St. Andrew. Ill. V. Gribayédoff (Cos–April.) 4000 w.

*20897. Further Developments in the Atlantic Race. Editorial (I & I–March 23.) 600 w.

*20920. The British Seas (Tr–March 23.) 2000 w.

*20928. A Lightship Electrically Connected with the Shore (C G–March 22.) 1200 w.

*20931. On Circulation in the Thornycroft Water-Tube Boiler. (Abstract.) J. I. Thornycroft (Eng L–March 23.) 1800 w.

*20932. On the Comparative Merits of Cylindrical and Water-Tube Boilers for Ocean Steamships.—With Discussion. (Abstract.) Mr. Howden (Eng L–March 23.) 4500 w.

*20935. On Water-Tube Boilers. Ill. J. T. Milton (Eng L–March 23.) 4000 w.

20946. Amended Steamboat Rules and Regulations of the Steamboat Inspection Service (Eng–March 31.) 5000 w.

21051. The Coast Survey. John Ritchie, Jr. (B C–April 7.) 1600 w.

21094. Insurance Tariffs for Wood and Iron Hulls (M R C–April 5.) 2000 w.

*21100. The Vibrations of Steamers. Ill. Otto Schlick (Eng L–March 30.) 5500 w.

*21102. The Movement in Shipbuilding. Editorial (Eng L–March 30.) 1500 w.

*21128. A Model Canadian Port (Tr–March 30.) 800 w.

Serials.

16636. Marine Engine Design (M W–Began Oct. 6—6 parts to date—30 cts. each).

19094. On Piratical Seas.—A Merchant's Voyages to the West Indies in 1805. Peter A. Grotjan (Sc M–Began Feb.—Ended April—3 parts—30 cts. each).

20142. The Resistance of Ships. Richard Lano Newman (J F I–Began March—Ended April—2 parts—45 cts. each).

20217. The Belgian Government Mail Steamer "Marie Henriette." Ill. (E–Began Feb. 23—Ended March 9—2 parts—30 cts. each).

20679. Criticism on Mr. Carlile's Article on "Water Tube Marine Boilers." E. E. Roberts (Am S–Began March 22—3 parts to date—15 cts. each).

20945. Origin and Development of Steam Navigation (Eng–Began March 31—1 part to date—15 cts).

MECHANICAL ENGINEERING.

*20432. The Curved Arms of Pulleys. Ill. (M W–March 2.) 600 w.

*20436. On Automatic Adjustments for Bearings. Ill. W. A. M'William (M W–March 2.) 1500 w.

20489. Experiment and Experience. B. F. Spalding (A M–March 15.) 2200 w.

†20494. A Machine for Curing India-Rubber Sap. Ill. M. F. Sesselberg (I R W–March 15.) 1200 w.

20519. The Power Absorbed by a 56-in. Circular Saw. Ill. Robert C. H. Heck and Henry B. Evans (E N–March 15.) 2800 w.

20660. The Emery Testing Machine. Ill. J. Sellers Bancroft (A M–March 22.) 6800 w.

20672. A Method for Calculating the Stresses in the Ferris Wheel. J. W. Schaub (E N–March 22.) 300 w.

20678. Edison's Kinetograph (M S P–March 17.) 750 w.

*20714. Has Farm Machinery Destroyed Farm Life? E. V. Smalley (F–April.) 4000 w.

*20757. The Castle in the Air. The Aerial Castle at the Antwerp Exhibition. Ill. (M–March 15.) 250 w.

*20798. Balancing Pulleys (M W–March 23.) 1200 w.

*20799. Motor Cycles. William Fletcher (P Eng–March 23.) 1800 w.

*20803. The Schiele Curve and the Friction of Thrust Bearings. Ill. R. E. Horton (A M–March 29.) 1600 w.

*20902. Hoisting Machinery. J. H. Allen (I C B–March 23.) 900 w.

20975. Some Recent Air Compressors. Ill. (S M–April 1.) 600 w.

20996. Making a Fusee or Derrick Barrel. Ill. Joseph Horner (A M–April 5.) 1800 w.

*21006. The Laws of Friction. R. James Abernathey (I S F–April.) 1100 w.

†21027. The Edson Recording Gauge. Ill. (J F I–April.) 1000 w.

†21028. Notes on the Design of Gear Wheels. Ill. L. F. Roudinella (J F I–April.) 2500 w.

*21114. On Making Joints (M W–March 30.) 1500 w.

*21130. The Band Saw (I C B–March 30.) 2500 w.

*21137. A New Arrangement of the Ordinary Siemens Valve. F. W. Paul (I C T–March 30.) 1900 w.

Serials.

16781. Rope Driving. J. J. Flather (E W–Began Oct. 21—10 parts to date—15 cts. each).

17117. English and American Testing Machines. Ill. (E Rev–Began Oct. 20—Ended March 20—3 parts—30 cts. each).

17362. Arithmetic of the Screw and of Symmetrical Rings. Leicester Allen (A M–Began Nov. 16—3 parts to date—15 cts. each).

18044. Motive Power and Gearing. E. Tremlett Carter (El–Began Dec. 1—10 parts to date—30 cts. each).

19638. Blowing Engines and Machinery. Ill. Albrech von Ihering (E M–Began Feb.—2 parts to date—30 cts. each).

19802. Mechanical Refrigeration. Ill. R. C. Carpenter (S J E-Began Feb.—2 parts to date—30 cts. each).

20580. Slide Rules and Calculations. Ill. (I C B-Began March 9—3 parts to date—30 cts. each.)

20750. A New System of Wheel Construction. Ill. Archibald Sharp (P Eng-Began March 16—3 parts to date—30 cts. each).

20900. Mechanical Drawing. Elementary Hints for Shop Men (T-Began April 1—1 part to date—15 cts).

21115. On an Overhead Power Travelling Crane. Ill. George Russell (M W-Began March 30—1 part to date—30 cts).

METALLURGY.

20380.—$1.50. A Proposed Method of Testing Structural Steel—Discussion on paper by Alfred E. Hunt (T C E-Dec.) 5600 w.

20381.—$1.50 The Use of Mild Steel—Discussion on paper by C. Weyrich (T C E-Dec.) 1700 w.

*20389. Forging by Hydraulic Pressure. (Abstract.) R. H. Tweddle (I & I-March 2.) 2000 w.

*20420. Blanzy Modifications in Appolt Coke Ovens. M. Marle (C G-March 2.) 2200 w.

*20464. Magnetism and the Makers of Iron. Sydney Evershed (El-March 2.) 1000 w.

*20465. On Methods of Testing the Magnetic Qualities of Iron—Discussion and editorial. Gisbert Kapp (El-March 2.) 7500 w.

†20467. A Plant for Granulating Slag. Richard H. Terhune (S M Q-Jan.) 800 w.

20499. The Sebenius Rotator for Steel Ingots. Ill. (Ir Age-March 15.) 1350 w.

*20561. Iron Ores and What We Pay for Them. Walter J. May (C G-March 9.) 1400 w.

*20570. Goldsmiths' Work: Past and Present, with discussion. Mrs. Philip Newman (J S A-March 9.) 7400 w.

20630. The Cost of Billets and of Rails (B I S-March 21.) 700 w.

*20643. The MacArthur Forrest Cyanide Process in Australia and South Africa (A M S-Jan. 27.) 1300 w.

20658. Comparative Density of Solid and Fluid Iron. I. McKim Chase (A M-March 22.) 650 w.

20661. Manganese in Foundry Iron. A. P. Bjerregaard (Ir Age-March 22.) 1100 w.

20662. Uniformity in Testing. P. Kreuzpointner (Ir Age-March 22.) 1700 w.

20677. Colorado Gold Mill Practice. Henry Vezin's Contribution to the Discussion of T. A. Rickard's paper on "Limitations of the Gold Stamp Mill" (M S P-March 17.) 800 w.

20717. Concentration of Copper Ores on Lake Superior. (Extract.) Ill. Fred Fraley Sharpless (A M & I W-March 23.) 2200 w.

*20752. Ore-Washer at Longdale, Virginia. Ill. Guy R. Johnson (C G-March 16.) 1200 w.

20783. Mold-Drying Apparatus. Ill. S. Groves (F D-March.) 600 w.

20784. The Feeding Rod. Ill. H. Hansen (F D-March.) 2000 w.

20807. The F. L. Bartlett Zinc-Lead Process. (Abstract.) E. W. Hawker (M S P-March 24.) 900 w.

20830. Influence of Silicon, Sulphur and Manganese on Foundry Irons. J. B. Nau (Ir Age-March 29.) 4000 w.

20831. Cupola Heat and Quality of Cast Iron. W. J. Keep (Ir Age-March 29.) 1700 w.

*20853. Some Experiments in Hardening and Annealing Steel. W. G. V. Lottes (L E April.) 1800 w.

20867. The Principal Smelting Reactions of Blast Furnace Slag, Considered on Thermo-Chemical Principles. A. D. Elbers (E M J-March 31.) 2500 w.

*20883. On the Carbon Reactions in the Blast Furnace. William John Hudson (I & S-March 24.) 7000 w.

20899. The Rusting of Iron and Steel (M G-March 31.) 800 w.

20947. Utilizing Sand Ores for Furnace Work. Walter J. May (A M & I W-March 30.) 1100 w.

20977. The Colors Produced During the Tempering of Steel. Thomas Turner (S M-April 1.) 1650 w.

*21111. The Eight Hours Day in the Iron and Engineering Trades (C G-March 30.) 1700 w.

*21136. The Estimation of Manganese in Minerals and Metals. (Abstract.) E. H. Saniter (I C T-March 30.) 2000 w.

*21138. Packing Iron and Steel Goods for Export (I C T-March 30.) 1600 w.

*21139. Bauxite (I & S-March 31.) 1000 w.

Serials.

12868. Present Condition of the Mechanical Preparation of Ores in Saxony, Hartz and Rhenish Prussia. M. Maurice Bellom (S M Q-Began April, 1893—4 parts to date—45 cts. each).

13033. Practical Hints to Boiler Makers and Templaters. Ill. (M W-Began May 12—7 parts to date—30 cts. each).

18900. The Protection of Iron and Steel from Corrosion. Ill. (I & I-Began Jan. 5—2 parts to date—30 cts. each).

19145. Cupola Management. Edward Kirk (Met W-Began Jan. 27—9 parts to date—15 cts. each).

19215. Canadian Iron Industry. George E. Drummond (C Eng-Began Jan.—3 parts to date—15 cts. each).

19676. The Manufacture of Aluminum. W. S. Sample (M W-Began Feb. 2—3 parts to date—30 cts. each).

20625. The Carbon Reactions in the Blast Furnace. William J. Hudson (I C T-Began March 9—Ended March 16—2 parts—30 cts. each).

20737. British Ore Producing Districts to Compete with Spanish Minerals. Walter J. May (Inv-Began March 10—2 parts to date—30 cts. each).

MILITARY ENGINEERING.

*20395. An American Cruiser on Service.—The Charleston (E–March 2.) 4000 w.

*20398. H. M. S. "Hornet" (E–March 2.) 2400 w.

20502. The Successful "Indiana." Ill (Sea–March 15.) 1100 w.

*20605. Foreign Naval Activity. Editorial. (I & I–March 9.) 1100 w.

*20695. The Burial of the Guns. Thomas Nelson Page (Sc M–April.) 9800 w.

*20709. The Gunnery Trials of H. M. S. "Barfleur" (E–March 16.) 4000 w.

*20710. The Qualities and Performances of Recent First Class Battleships—with Discussion. W. H. White (E–March 16) 16000 w.

20720. How War Vessels Are Prepared for Trial. Robert W. Peck (M R C–March 22.) 2500 w.

*20739. Recent Experiments in Armor. C. E. Ellis (I C T–March 10.) 5000 w.

*20774. The Making of a Modern Fleet. W. H. White (Eng L–March 16.) 4000 w.

*20776. Boilers for Torpedo Catchers. Editorial (Eng L–March 16.) 2000 w.

20811. A Battle-Ship in Action. S. A. Staunton. (Extract from Harper's Magazine.) (Sea–March 29.) 2000 w.

20820. Some Uses of Snow Shoes. Ill. (From the London Graphic.) (Sc A S–March 31.) 1800 w.

20829. Tube Sheets and Tubes of Boilers of War Ships. Ill. (Ir Age–March 29.) 1000 w.

*20891. Turret and Turret-Moving Machinery of the United States Battleship "Texas." Ill. (A E R J–April.) 3300 w.

*20912. The Navy Estimates. Editorial (E–March 23) 3200 w.

*20933. The New Naval Programme. Editorial (Eng L–March 23.) 1800 w.

*20934. British Armor and Ordnance. Editorial (Eng L–March 23.) 1200 w.

20943. Shall We Have an American Navy? Editorial (Eng–March 31.) 1400 w.

21007. Our New Navy.—Big Guns for Big Ships (Sea–April 5.) 1300 w.

*21103. Electric Signals for War Ships. Ill. (Eng L–March 30.) 3800 w.

Serials.

20068. The Future of Naval Warfare. H. Middleton (Inv–Began Feb. 17—5 parts to date—30 cts. each).

20396. Armstrong Quick-Firing Guns. Ill. (E–Began March 2—Ended March 16—3 parts—30 cts. each).

MINING.

*20360. Gold and Silver Mining in South America. Arthur L. Pearse (E Mag–May.) 4500 w.

20388. The Asbestos Fields of Port-au-Port, Newfoundland. Ç. E. Willis (C Eng–March.) 1500 w.

*20403. American Quarrying Methods. Ill. Arthur Lee (I C B–March 2.) 400 w.

*20421. Mechanical Appliances for the Shipment of Coal. S. W. Allen (C G–March 2.) 7500 w.

*20423. Notes on an Occurrence of Manganese and Zinc Ore in Nova Scotia. E. Gilpin, Jr. (C G–March 2.) 1000 w.

*20424. Colliery Ventilating Machinery. (Extract.) C. M. Percy (C G–March 2.) 2400 w.

*20425. The Petroleum Industry in Galicia. M. D. Bellet (C G–March 2.) 800 w.

20509. California Mines at the Midwinter Fair (M S P–March 10) 1700 w.

20510. The Gold Mines of Plumas. J. A. Edman (M S P–March 10.) 900 w.

20539. The Sudbury Nickel Region. Ill. E. Renshaw Bush (E M J–March 17.) 3400 w.

20540. The Githens System of Rock Drilling. Ill. (E M J–March 17.) 1100 w.

20541. Canadian Lake Iron Ores. J. G. Donald (E M J–March 17.) 600 w.

*20562. Screening and Washing Floors at the Blanzy Collieries. Daniel Graillot and Dupont de Dinechin (C G–March 9.) 3000 w.

*20564. Fumat Safety Lamp (C G–March 9.) 1100 w.

*20565. The Coal Mines of West Virginia. (Abstract.) Arthur Peel (C G–March 9.) 2500 w.

20595. Coal. A. W. Wilkinson (A G L J–March 19.) 1000 w.

*20642. A Visit to the Pyrites Mines of Spain. Ill. Edward D. Peters, Jr. (A M S–Jan. 27.) 2200 w.

*20644 The Mining Industry.—Queensland.—Charters Towers.—Croydon (A M S–Feb. 3.) 3000 w.

*20646. The Bonnie Dundee Gold Mine, Queensland. Ill. (A M S–Feb. 10.) 600 w.

*20648. Auriferous Beaches on the North Coast (N. S. W.) (A M S–Feb. 17.) 2000 w.

*20649. Ceylon Gem Stones (A M S–Feb. 17.) 600 w.

20681. The Gas Engine in Mine and Mill Plants (E M J–March 24.) 1000 w.

20683. The Occurrence of Gold in the Ores of the Cripple Creek District. (Abstract.) Richard Pearce (E M J–March 24.) 900 w.

*20751. Briquette Factories at the Blanzy Collieries. Dupont de Dinechin (C G–March 16.) 1700 w.

*20753. Coking Anthracite and Non-Coking Coal Slack. Walter J. May (C G–March 16.) 1500 w.

*20754. The Parkside Hematite Mines, Cumberland. M. E. (C G–March 16.) 2000 w.

*20755. The Yorkshire Coalfield. G. E. J. McMurtrie (C G–March 16.) 1800 w.

*20762. Antiquity of Slate. George H. Harris (S–March.) 1400 w.

*20763. The Sandstones of Lake Superior. Henry G. Rothwell (S–March.) 3000 w.

*20775. Petroleum in Somersetshire. Editorial (Eng L–March 16.) 1300 w.

20806. Side Lines and End Lines.—Justice Field's Decision in the Case of Silas F. King vs. Amy and Silversmith Consolidated Mining Company (M S P–March 24.) 1800 w.

*20850. Notes on the Lower Coal Measures of Western Clearfield County, Pennsylvania. J. F. Kemp (I. H P–March.) 1200 w.

20865. The New Gold Fields of the Mosquito Coast of Nicaragua. Courtenay De Kalb (E M J–March 31.) 1150 w.

20872. A Phantom of the Mines. Ill. Robert Howard Syms (Cos–April.) 4500 w.

*20888. Electric Conductors for Fiery Mines. Joseph Libert (El–March 23.) 3000 w.

*20926. A Comparison of Some Systems of Machine Screening. (Abstract.) Ill. G. E. J. McMurtrie (C G–March 22.) 2700 w.

*20927. The Working and Concentration of Dean Forest Hematites. Walter J. May (C G–March 22.) 1200 w.

21010. A Practical Talk on Mining Geology. Taylor D. MacLeod (M S P–March 31.) 1300 w.

21011. Mechanical Arrangements in Underground Operations. Extracts from paper of R. H. Wynne (M S P–March 31.) 900 w.

*21035. Cripple Creek.—Topographical and Geological Information. Ill. A. C. Lakes (C E–April.) 5000 w.

*21036. Coal Dust in Mines. Editorial (C E–April.) 1000 w.

*21037. A Complete Coke Plant.—Sewanee Mines, Tracy City, Tenn. Ill. Charles Edward Bowron (C E–April.) 2000 w.

21047. Bituminous Coals Differ in Value (B J C–April 7.) 1000 w.

21097. The Loss of Money in Investments in England (E M J–April 7.) 1300 w.

21098. Fire Doors for Mine Shafts. Ill. R. G. Brown (E M J–April 7.) 500 w.

21099. A Remarkable Folded Vein in the Ready Relief Mine. Ill. Harold W. Fairbanks (E M J–April 7.) 800 w.

*21104. The Utilization of Waste Coal. Ill. (I & I–March 30.) 2400 w.

*21106. Wheelock Winding Engine of the Blanzy Colliery. Léonard Graillot (C G–March 30.) 1800 w.

*21108. The Removal of Pyrites from Small Coal. Walter J. May (C G–March 30.) 800 w.

*21109. Explosion of Fire Damp Due to an Overcharged Shot. Ill. (C G–March 30.) 2000 w.

*21113. American vs. British Coal. (G W–March 31.) 2600 w.

*21129. Mining in Canada Region—A Rich Silver Country. (Min W–March 31.) 1300 w.

*21153. The Marble Quarries of Carrara. Ill. Arthur Lee (S–April.) 1600 w.

*21154. The Marbles of Lower Unzimkulu. Natal. J. B. & D. C. Aiken (S–April.) 1600 w.

Serials.

9459. The Manufacture of Coke. Ill. John Fulton (C E–Began Jan., 1893—15 parts to date—30 cts. each).

11282. Mine Ventilation Made Easy. W. Fairley (C E–Began March, 1893—13 parts to date—30 cts. each).

11801. Information to Aid in the Search of Gold and Silver. Ill. Arthur C. Lakes (C E–Began April, 1893—Ended April, 1894—13 parts—30 cts. each).

11804. Fire Damp. H. Le Chatelier. Translated by H. Stoek (C. E–Began April 1893—Ended March, 1894—11 parts—30 cts. each).

12450. The Coal Fields of Canada. Ill. William Hamilton Merritt (C E–Began May—12 parts to date—30 cts. each).

19079. Talks on Quarrying. Ill. Edward H. Williams, Jr. (S–Began Jan.—3 parts to date—30 cts. each).

19682. The Sinking and Equipment of Shafts. Ill. (E–Began Feb. 2—3 parts to date—30 cts. each).

19919. North Queensland Goldfields (A M S–Began Jan. 6—5 parts to date—30 cts. each).

20407. Mine Surveying Methods Employed in the Coalfields of Pennsylvania. Otto C. Burkhart (C E–Began March—2 parts to date—30 cts. each).

20413. Mining Methods. Ill. (C E–Began March—2 parts to date—30 cts. each).

20414. Geology of Coal. Ill. (C E–Began March—2 parts to date—30 cts. each).

20415. Mining Machinery. Ill. (C E–Began March—2 parts to date—30 cts. each).

20416. Chemistry of Mining. Ill. (C E–Began March—2 parts to date—30 cts. each).

20223. The Cumberland Coalfield. (C G–Began Feb. 23—5 parts to date—30 cts. each).

20682. The Coal Measures of Iowa. Ill. Charles R. Keyes (E M J–Began March 24—Ended April 7—3 parts—15 cts. each).

20711. Oil Creek in the Sixties. (O P D R–Began March 26—Ended April 2—2 parts—15 cts. each).

RAILROADING.

*20359. Inclined Railway Systems of the World. Ill. Theodore C. Ives (E Mag–May.) 3000 w.

20370.—$1.50. Discussion on paper by C. D. Purdon—"Comparison of Modern Engine-Loading with Standard Specifications for Spans from 10 to 200 ft." (T C E–Dec.) 2500 w.

20371—$1.50. "Surveys for Railway Location"—Discussion of paper by F. A. Gelbcke (T C E–Dec.) 2800 w.

20372.—$1.50. Discussion on paper by E. A. Ziffer "On the Guages of Railroad Track, etc." (T C E–Dec.) 2800 w.

*20448. A Miniature Gravity Railway. Ill. (Eng L–March 2.) 4800 w.

20462. Steam Distribution for High Speed Locomotives. (Extract.) C. H. Quereau (R R–March 10.) 2700 w.

20463. English Board of Trade Regulations Regarding Signals, etc. (R R–March 10.) 1300 w.

†20476. Railway Development at Home and Abroad. J. Stephen Jeans (F R–March.) 5000 w.

20513. Some Results of the Stewart Avenue Pneumatic Interlocking. (R G–March 16.) 1300 w.

20515. Air Brakes and Their Maintenance—Abstract of Discussion on paper by G. W. Rhodes. (R G–March 16.) 2000 w.

20516. Steel Rail Specifications (R G–March 16.) 1000 w.

20517. Some of the New Railroad Work in London (R G–March 16.) 1500 w.

*20518. The Strategic Value of American Railways.. T. C. Scoble (A J R A–March.) 2700 w.

20522. Recent Schemes for Electric Locomotives (E N–March 15.) 1600 w.

20547. Lubrication of Journals. F. D. Adams (R C J–March.) 2800 w.

20548. Bearing Materials and Lubrication. W. C. Dallas (R C J–March.) 1600 w.

*20593. French Commerce, Navigation and Railways (Tr–March 9.) 1500 w.

*20603. The Eisenerz-Vordernberg Abt Railway, Austria. Ill. (I & I–March 9.) 500 w.

*20606. A Run with "Petrolea." Charles Rous-Marten (Eng L–March 9) 4600 w.

*20614. The Forthcoming Railway Congress. Editorial (E–March 9.) 1800 w.

20622. "Lying, Cheating and Stealing."—Remarkable Charge by the Louisville and Nashville against Competing Lines, with Editorial. M. H. Smith (R A–March 16.) 7000 w.

20631. The Ball Balanced Compound Locomotive. Ill. (R R–March 17.) 1000 w.

20664. A Difficult Piece of Construction in London. C. H. G. (R G–March 23.) 900 w.

20665. Old English Locomotives. Ill. (R G–March 23.) 650 w.

20666. A Railroad Connecting the Shores of the Arctic with St. Petersburg (R G–March 23.) 850 w.

20667. A Movement to Use Green for an "All Clear" Night Signal. Editorial (R G–March 23.) 1800 w.

20668. Cheap Railroad Working in India (R G–March 23.) 3000 w.

20669. Counterbalancing in the Laboratory and on the Track (R G–March 23.) 1200 w.

*20713. Has the Inter-State Commerce Law Been Beneficial? Aldace F. Walker (F–April.) 4800 w.

*20719. Electric Roads in Country Districts. (Reprint from N. Y. Evening Post.) (S R E N–March.) 1500 w.

20724. State Supervision of Railway Crossings (R A–March 23.) 900 w.

*20733. Locomotive Builders Drafting Room System. J. S. Reid (S J E–March.) 2500 w.

*20738. Russian Railways and Waterways (Tr–March 16.) 900 w.

20778. Need for and Plan of Disseminating Knowledge Concerning Railways. George de Haven (R R–March 24.) 4200 w.

20781. Dynamometer Car on the Paris, Lyons and Mediterranean Railway, with Editorial. Ill. (R R–March 24.) 2500 w.

20834. Railway Development and Commerce in the Republic of Colombia (E N–March 29.) 1600 w.

20842. Comparative Tests of English and American Railroad Trains. Ill. (R G–March 30.) 3500 w.

20843. The Ninety-Third Street Subway under the Illinois Central Railroad Tracks. Ill. (R G–March 30.) 1200 w.

20844. Mr. Depew on the Trunk-Line Situation (R G–March 30.) 1400 w.

20845. Grade Crossing Laws (R G–March 30.) 900 w.

20846. Track Elevation in Chicago (R G–March 30.) 2000 w.

20851. Differential Block System. Ill. (W E–March 31.) 1000 w.

*20852. A Railroad Profile of Some Use. C., St. P. and K. C. R'y. Ill. (L E–April.) 300 w.

20863. $1.50. Railroad Location, with Discussion. Michael L. Lynch (T C E–Jan.) 18800 w.

*20886. The Board of Trade Electric Traction Regulations, with Editorial (El–March 25.) 3000 w.

*20913. The Great Venezuelan Railway (E–March 23.) 1400 w.

*20921. Railway Accident Insurance in Prussia (Tr–March 23.) 600 w.

*20922. French Train Speeds (Tr–March 23.) 700 w.

*20939. A System of Tracing Train Delays. (N C B–April.) 550 w.

20957. Queen and Crescent Answers Louisville and Nashville. S. M. Felton (R A–March 30.) 1800 w.

20958. Quirk's Train Tablet Exchange. Ill. (R A–March 30.) 1100 w.

20961. The Herculaneum Bridge Disaster and Public Prejudice Against Railways. Quinton McNab (R R–March 31.) 900 w.

20963. Advanced or Back Charges. Editorial (R R–March 31.) 1100 w.

21013. The Construction of a Short Tunnel; W. Va. and P. R. R. (Abstract.) Ill. J. G. G. Kerry (E N–April 5) 3200 w.

21019. Some Track Buffers. Ill. James F. Hobart (R G–April 6.) 1300 w.

21020. What Is an Economical Load for a Locomotive? (Abstract.) George W. West (R G–April 6.) 1000 w.

21022. The International Railroad Congress. Editorial (R G–April 6.) 1200 w.

21071. Terminal Yards. J. B. Morford (R A–April 6.) 1000 w.

*21088. London, Chatham, and Dover Express Engines. Ill. Clement E. Stretton (R W–March.) 900 w.

*21090. Pullman Cars. Ill. (R W–March.) 1800 w.

*21091. The Vacuum Automatic Brake.—Messrs. Gresham and Craven's Works. Ill. (R W–March.) 3600 w.

*21127. Market Traffic Rates in Europe and America (Tr–March 30.) 1500 w.

*21134. Railway Extension in India, and Its Relation to the Trade of India and of the United Kingdom, with Discussion. Joseph Walton (J S A–March 30.) 8800 w.

21146. The Locomotive "General." Ill. (R R–April 7.) 900 w.

21148. Documents to Be Sent to the Railway Department, Board of Trade, Previously to the Second Notice of the Intention to Open a Railway Being Given (R R–April 7.) 3500 w.

Serials.

12001. Rails on the Creep. A. Ewbank (I E–Began March 11, 1893—43 parts to date—45 cts. each).

15496. Railroad Coppersmithing. Ill. John Fuller, Sr. (L E–Began Sept.—8 parts to date—30 cts. each).

17464. Vancouver to Chicago. Killingworth Hedges (I & I–Began Nov. 10—4 parts to date—30 cts. each).

17826. Evolution of the Air Brake. Ill. Paul Synnestvedt (R E M–Began Dec.—5 parts to date—15 cts. each).

18435. Painting a Railway Passenger Car. A. Ashmun Kelly (R E M–Began Jan.—3 parts to date—15 cts. each).

18957. Ventilation of Passenger Cars. James F. Hobart (R C J–Began Jan.—4 parts to date—15 cts. each).

20112. Vestibules, Platform Canopies and Hoods. Ill. (R G–Began March 2—Ended March 23—3 parts—15 cts. each).

20611. The Mont Selève (Geneva) Electric Rack Railway. Ill. C. S. Du Riche Preller (E–Began March 9—2 parts to date—30 cts. each).

20632. Railway Management. Horace Cope (R R–Began Dec. 1, 1892—11 parts to date—15 cts. each).

20780. Rail Depression and Strain under Locomotives. Ill. (R R–Began March 24—2 parts to date—15 cts. each).

20892. Signal Apparatus in Use on the Grand Central Railway of Belgium. Leopold Kirsch (A E R J–Began April—1 part to date—30 cts).

20959. Ought the Government to Own the Railways? George H. Lewis (R R–Began March 31—2 parts to date—15 cts. each).

20962. Track Maintenance. Edward Laas (R R–Began March 31—2 parts to date—15 cts. each).

STREET RAILWAYS.

*20362. The Storage Battery and Its Uses. Townsend Wolcott (E Mag–May.) 3000 w.

20373.—$1.50. "Transmission of Power in Operating Cable Railways"—Discussion of paper by Robert Gillham (T C E–Dec.) 3200 w.

*20456. The Liverpool Overhead Railway (I C T–March 2.) 1800 w.

20474. Capacity of Railway Motors. E. A. Merrill (E E N Y–March 14.) 650 w.

*20508. Rapid Transit Possibilities—The Moving Platform System. Ill. (E M–March.) 900 w.

20514. The "Hillside" Loops of the North Hudson County Railway. Ill. (R G–March 16.) 600 w.

†20557. Discussion of Paper by H. Ward Leonard on "How Shall We Operate an Electric Railway 100 Miles From the Power Station," with description of apparatus (T A I E E–March.) 10500 w.

20566. Advisability of Insurance of Street Railway Companies Against Liability for Wrong Doing. R. D. Fisher (S R G–March 17.) 800 w.

*20602. The Liverpool Overhead Railway—Abstracts of papers by Messrs. Greathead and Fox, and T. Parker, with discussion (I & I–March 9.) 5800 w.

*20619. Storage Battery Traction for Street Tramcars. Editorial (P Eng–March 9.) 1200 w.

20656. The Waddell-Entz Storage Battery Car Traction Plant of the Second Avenue Railroad Company, New York (Sc A–March 24.) 1700 w.

*20694. Storage Battery Cars. George J. Varney (L Mag–April.) 1800 w.

20786. Rapid Transit. (Extract.) Albert L. Clough (S R G–March 24.) 2000 w.

20787. The Aerodromic System of Transportation. Ill. (E R N Y–March 28.) 1300 w.

20789. The Barrows System of Transportation. Ill. (E R N Y–March 28.) 1300 w.

20841. Rapid Transit in Baltimore. J. C. Ransom (R G–March 30.) 1400 w.

20954. Paris Underground Electric Railway. Ill. (S R G–March 31.) 700 w.

20972. The Silvey Storage Car System. Ill. (E E N Y–April 4.) 2400 w.

20978. Steam Tramcars With Serpollet's Boiler. Ill. (Sc A–April 7.) 1300 w.

†20989. A Modern Car House—Citizens Traction Co., Pittsburg, Pa. Ill. (S R J–April.) 1350 w.

†20991. Narrow vs. Broad Gauge Electric Railways. E. A. Merrill (S R J–April.) 1500 w.

†20992. Proper Rail Bonding. (Abstract.) H. J. Malochee (S R J–April.) 2300 w.

†20993. Street Railways in Montgomery, Mobile and New Orleans. Ill. (S R J–April.) 10500 w.

21072. Electric Power Plant for the New Haven Street Railway Company. Ill. (E I–April.) 1000 w.

*21089. The Dresden Electric Tramway. Ill. (R W–March.) 1600 w.

Serials.

18549. The Intrinsic Value of Street Railway Investments. Edward E. Higgins (S R J–Began Jan. 1—4 parts to date—45 cts. each).

18711. Electric Railway Motors: Their Construction and Operation. Ill. Nelson W. Perry (S R G–Began Jan. 6—13 parts to date—15 cts. each).

19306. The Third Avenue Cable Railway of New York City. Ill. (E N–Began Feb. 1—4 parts to date—15 cts. each).

20206. The Electric Tramway at Remscheid. Ill. Julius Maier (E L–Began Feb. 23—2 parts to date—30 cts. each).

21092. The Relative Economy of Cable and Electric Tramways (R W–Began March—1 part to date—30 cts).

SANITARY ENGINEERING.

*20366. An Unsettled Question in Ventilation. Leicester Allen (E Mag–May.) 2000 w.

20383.—$1.50. Purification of Sewage and of Water by Filtration.—Discussion on paper by Hiram F. Mills (T C E–Dec.) 2500 w.

*20386. Sewer Gas and Zymotic Disease. A. C. Ranyard (K–March 1.) 3800 w.

*20397. Public Health. Editorial (E–March 2.) 2700 w.

20534. The Sanitation of Santos, Brazil. Ill. (E R–March 17.) 2600 w.

*20559. Sanitary Inspectors. — Tenure of Their Appointments (S R–March 10.) 1500 w.

*20575. The Hermite Sanitary Process (E R L–March 9) 1300 w.

20623. Heating and Ventilation (R & T–March.) 2800 w.

*20707. The Submerged Sewer at Shirley Gut, Boston, Mass. (E–March 16.) 2000 w.

†20810. Experiments with Glazed Stoneware Pipes (I E–Feb. 24.) 600 w.

20835. Drinking Water at the World's Columbian Exposition. Allen Hazen (E N–March 29.) 1500 w.

†21024. Out of Sight, Out of Mind.—Methods of Sewage Disposal. George E. Waring, Jr. (C M–April.) 10000 w.

Serials.

5358. Sewage Purification in America. Ill. (E N–Began July 14, 1892—40 parts to date—15 cts. each).

10425. A Healthy Home. Francis Vacher (S R–Began Feb. 1, 1893—Ended March 24, 1894—28 parts—30 cts. each).

18870. Humidity and Ventilation. Joseph Masinette (A Ar–Began Jan. 13—3 parts to date—15 cts. each).

19813. American Plumbing (D E–Began Feb.—2 parts to date—30 cts. each).

20014. Plumbing in the Metropolitan Building. Ill. (E R–Began Feb. 24—2 parts to date—15 cts. each).

20194. Sewage Disposal. George E. Waring, Jr. (E R–Began March 3—2 parts to date—15 cts. each).

21132. Sanitary Law. A. Wynter Blyth (I C B–Began March 30—1 part to date—30 cts).

STEAM ENGINEERING.

*20447. Circulation in Water-Tube Boilers. Editorial (Eng L–March 2.) 2000 w.

20481. Some Ancient Reaction Engines. Ill. W. F. Durfee (Sc A–March 17.) 1700 w.

20490. Lubricators and Lubrication. W. H. Wakeman (A M–March 15.) 700 w.

20491. An Instance of Steam Economy. Edward J. Willis (A M–March 15.) 700 w.

*20507. Losses of Heat in Combustion of Fuels (E M–March.) 3000 w.

20543. Origin and Development of Steam Navigation (Eng–March 17.) 2500 w.

20544. Returns in Heating Systems.—How Check Valves Should be Arranged. Ill. (B J C–March 17.) 500 w.

20545. Anti-Friction Materials.—Their Use as Dry Bearings for Machinery (B J C–March 17.) 1700 w.

*20607. On the Systematic Production of Steam from Sixty-eight Boilers at the "Say" Sugar Refinery, Paris. Ill. Bryan Donkin (Eng L–March 9.) 4500 w.

20654. How to Operate a Steam Boiler. Jarvis B. Edson (E E N Y–March 21.) 3500 w.

20684. About Chimneys.—The Importance of Height (B J C–March 24.) 1000 w.

20731. Steam Boilers and Treatment and Purification of Water (M G–March 24.) 4000 w.

*20740. Leaves from a Laboratory Note Book. Some Points Affecting the Transmission of Heat in Steam Boilers. Vivian B. Lewis (I C T–March 10.) 3000 w.

*20777. Some Experiments with Triple-Expansion Engines at Reduced Powers. D. Croll (Eng L–March 16.) 1900 w.

20804. Locomotives as Stationary Engines. Editorial (A M–March 29.) 1100 w.

20805. The Development of the Steam Engine Indicator. (Extract.) Harris Tabor (A M–March 29.) 3300 w.

20819. New Steam Carriage. Ill. (Sc A–March 31.) 1500 w

20822. Cracked Plates. Ill. (S E–Jan.) 1300 w.

20837. Sulzer Triple-Expansion Vertical Engine of 1300 H. P. Ill. (E N–March 29.) 600 w.

*20854. Cylinder Compensation. Editorial (L E–April.) 1300 w.

20942. Repeating Apparatus for Indicators. Ill. George Sieurin (P S–April.) 600 w.

20970. Progress in Exhaust Steam Heating. J. H. Babcock (E E N Y–April 4.) 800 w.

20974. The Indicated Horse Power of a Compound Condensing Engine. W. H. Wakeman (S M–April 1.) 400 w.

*21005. The Evolution of Steam Engines. John E. Sweet (I S F–April.) 4800 w.

*21032. The Lancashire Boiler. Ill. W. H. Booth (C E–April.) 800 w.

21046. Steam Engine Design.—Advantages of the Different Types (B J C–April 7.) 1600 w.

21050. The Limitation of Engine Speed (M G–April 7.) 2000 w.

*21061. The Livet System of Generating Steam by the Destruction and Combustion of Town Refuse. Ill. (M–Feb. 15.) 1800 w.

*21063. Coal and "Coal." Editorial (El–March 30.) 1000 w.

*21076. Fractures in Caustic Soda Boilers. Editorial (P Eng–March 30.) 1200 w.

*21086. Morton's Steam Turbine. Ill. (E R L–March 30.) 1600 w.

*21101. Mr. Croll on Condensation in Cylinders. Editorial (Eng L–March 30.) 1600 w.

Serials.

11138. Notes on the Steam Injector. Ill. Strickland L. Kneass (E M–Began March, 1893.—Ended April, 1894—14 parts—30 cts. each).

17823. Designing Corliss Gears. Ill. James Dunlop (P Eng—Began Nov. 24—6 parts to date—30 cts. each).

18986. Boiler Calculations. James F. Hobart (S M–Began Jan. 15—4 parts to date—15 cts. each).

19709. The Indicator and Its Diagrams. Ill. Charles Day (P Eng–Began Feb. 2—6 parts to date—30 cts. each).

20182. The Elements of Boiler Making. C. E. Fourness (L E–Began March—2 parts to date—30 cts. each).

20568. The Stationary Engineers as They Were and as They Are. Stephen Roper (S V–Began March 15—1 part to date—15 cts).

20680. The Steam Jacket. Thomas Main (Am S–Began March 22—3 parts to date—15 cts. each).

21064. The Testing of Engines and Boilers. Alex. B. W. Kennedy (El–Began March 30—1 part to date—30 cts).

21141. High Speed Steam Engines. John Radinger (E M–Began April—1 part to date—30 cts).

TELEPHONY AND TELEGRAPHY.

*20616. The Telegraph Engineers in India. Editorial (E–March 9.) 900 w.

20628. $50,000,000 for Telephoning.—The American Bell Telephone Company's Argument for Increase of Capital. (E R N Y–March 21.) 5500 w.

†20637. A Century of the Telegraph in France. Ill. Walter Lodian (P S M–April.) 2500 w.

20703. A Phase of Telephone Engineering. Angus S. Hibbard (E E–March.) 2200 w.

*20736. A History of the Telephone and the Expiry of Original Patents. (Inv–March 10.) 2800 w.

20985. Steering by Telephone in a Fog. (Reprint from Pall Mall Gazette.) (E R N Y–April 4.) 600 w.

20987. The Carbon Telephone Patents. Editorial (E R N Y–April 4.) 1800 w.

20994. A Telephone Cable Test. C. W. Swoope (E N Y–April 4.) 300 w.

21049. The Repeating Coil as Used in Telephony. Ill. W. H. Hyde (W E–April 7.) 1200 w.

*21081. Graham's Electric Loud Talking Apparatus. Ill. (Inv–March 31.) 600 w.

*21083. Electric Communication between Lightships and the Shore. Editorial (Inv–March 31.) 600 w.

Serials.

18628. The Electro-Magnet; or Joseph Henry's Place in the History of the Electro-Magnetic Telegraph. Ill. Mary A. Henry (E E N Y–Began Jan 3—8 parts to date—15 cts. each).

20069. Visual Telegraphy.—A Review of the Work in this Field. Ill. N. S. Amstutz (E N Y–Began Feb. 28—3 parts to date—15 cts. each).

MISCELLANEOUS.

*20357. Wider Markets for American Manufactures—The Industrial Problem of the Day. Hawthorne Hill (E Mag–May.) 3000 w.

*20361. The Northern White Pine Industry. Ill. Richard A. Parker (E Mag–May.) 3000 w.

20377.—$1.50. "Topographic Surveys." Ill. Discussion on paper by Herbert G. Ogden (T C E–Dec.) 9000 w.

20378.—$1.50. The Use of Long Steel Tapes. Discussion on paper by R. S. Woodward (T C E–Dec.) 3500 w.

*20393. Technical vs. Literary Education. Editorial (I & I–March 2.) 1000 w.

*20405. The Observation and Creation of Beauty. William Morris (A L–March 2.) 3200 w.

*20406. The Arts and Industries of Belgium, and the Antwerp Exposition, 1894—with Discussion. Edward Sève (J S A–March 2.) 11800 w.

*20454. Flying Machines. Gavin J. Burns (S L–March.) 2000 w.

*20457. Engineers of To-Day and Yesterday. John Fritz—W. H. Jaques. Ill. (E Rev–Feb. 20.) 2000 w.

†20468. A Relation of Engineering to Progress and Civilization. F. R. Hutton (S M Q–Jan.) 2000 w.

†20471. Scientific Problems of the Future. H. Elsdale (C R–March.) 6300 w.

†20477. From Cape Town to Cairo. Henry W. Lucy (F R–March.) 4900 w.

†20492. The Caoutchouc Supply from British India. Clements R. Markham (I R W–March 15.) 4800 w.

†20493. I. The Proper Place for Rubber Cultivation. Courtenay DeKalb. II. Articles on Rubber Culture (I R W–March 15.) 2500 w.

*20523. Toronto Technical School (Can A–March.) 3000 w.

*20524. Rocks. A. P. Coleman (Can A–March.) 2000 w.

†20531. Mortgage Banking in America. D. M. Frederiksen (J P E–March.) 8700 w.

†20538. The Land Laws of New Zealand. Edward Reeves (W R–March.) 4000 w.

*20608. Paris a Seaport. Editorial (Eng L–March 9.) 1500 w.

20634. The Position and Prospects of Aerial Navigation (Min R–March 15.) 1500 w.

†20636. New Lights on the Problem of Flying. Ill. Joseph Le Conte (P S M–April.) 5500 w.

†20638. On New England and the Upper Mississippi Basin in the Glacial Period. James D. Dana (P S M–April.) 1400 w.

†20639. The Origin of Art. W. Lazar Popoff (P S M–April.) 2800 w.

*20651. The Evolution of a Statue. F. Weitenkampf (Ch–April.) 3400 w.

20699.—$1. A History of Political Economy. Gustav Cohn (An A A–March.) 45000 w.

20705.—$1. The Idea of Justice in Political Economy. Gustav Schmoller (An A A–March.) 13300 w.

*20712. What "Americanism" Means. Theodore Roosevelt (F–April.) 5500 w.

*20732. An Address to Young Engineers. George W. Melville (S J E–March.) 3000 w.

*20756. The Newest Flying Machine. The "Maxim" Air-Ship Inspected and Described. (M–March 15.) 2300 w.

20782. A Trade or a Profession? C. R. Tompkins (A S–March 24.) 1000 w.

†20795. Tariff Reform and Monetary Reform. E. B. Andrews (N A R–April.) 5600 w.

†20796. An Anglo-American Alliance. Arthur Silva White (N A R–April.) 4000 w.

†20797. How We Restrict Immigration. Joseph H. Senner (N A R–April.) 2400 w.

20838. Abolishing the Coast and Geodetic Survey (E N–March 29.) 1400 w.

*20868. The Indian Currency, with Discussion. J. Barr Robertson (J S A–March 23.) 33000 w.

20877. Flying Devices. Ill. George Crosland Taylor (Aer–April.) 5000 w.

20878. The Flying Man. Ill. Otto Lilienthal (Aer–April.) 5200 w.

*20890. The Problem of Man Flight. Editorial (Inv–March 24.) 2000 w.

*20894. Men of Metal. Hiram S. Maxim (I & I–March 23.) 3000 w.

*20916. A Technical Utopia, Limited.—Currie Residential Technical Schools, Folkestone. Ill. (E R L–March 23.) 5000 w.

*20917. Engineers of To-day and Yesterday.—James Brindley—Edward Leader Williams. Ill. (E Rev–March 20.) 3300 w.

*20923. Josiah Wedgwood (A L–March 23.) 2000 w.

*20950. Popular Mistakes About Taxation (S Ec–April.) 2400 w.

*20951. Economic Theory Concerning Value. Van Buren Denslow (S Ec–April.) 3800 w.

20976. Mechanical Engineering Building of the Case School of Applied Science. Ill. (S M–April 1.) 1000 w.

20979. Carborundum. Ill. (Sc A–April 7.) 1300 w.

21014. Wire Glass (E N–April 5.) 1500 w.

21023. A Raid on the Coast Survey (R G–April 6.) 1500 w.

*21026. Negro Progress on the Tuskegee Plan. Ill. Albert Shaw (R of R–April.) 4500 w.

*21055. Theory and Practice. Gavin J. Burns (S L–April.) 1700 w.

†21066. On a New Horizon and Some New Localities for Friable Sandstone in Which the Grains are Enlarged by Secondary Deposition of Silica in Optical Continuity with the Original Nucleus. Ill. Samuel Calvin (A G–April.) 1000 w.

†21068. A Classification of Economic Geological Deposits Based on Origin and Original Structure. W. O. Crosby (A G–April.) 6000 w.

†21069. Geology of Jefferson County, Texas. W. Kennedy (A G–April.) 2000 w.

†21070. British Drift Theories. Warren Upham (A G–April.) 1000 w.

*21124. Irish Geology (A L–March 30.) 1200 w.

*21125. The Excavation of Deir el Bahari (A L–March 30.) 1400 w.

*21126. Nature and Art. (Extract.) F. Suddards (A L–March 30.) 1500 w.

*21135. The Har Dalam Cavern and Its Ossiferous Contents (N–March 29.) 1200 w.

†21166. Pages in the History of Allotments. J. Frome Wilkinson (C R–April.) 5700 w.

21189. The Maxim Air Ship. Ill. H. J. W. Dam (Sc A–April 14.) 4800 w.

21219. Sectional Lenses. (Reprint from the Chicago Tribune.) (Eng.–April 14.) 800 w.

21227. Scientific Work at Cornell (R G–April 13.) 1400 w.

*21277. The Elements of Beauty in Ceramics. Charles F. Binns, with Discussion (J S A–April 6.) 7400 w.

*21295. Engineering Works on the Thames. Messrs. John and Henry Gwynne. Ill. (Eng. L–April 6.) 4500 w.

*21305. Wedgwood as a Potter (A L–April 6.) 2000 w.

*21320. The Production of Artificial Marble According to the Moreau-Rae Process (Inv–April 7.) 1500 w.

†21322. What may happen to a British Captain—The "Costa Rica Packet" Case. J. F. Hogan (W R–April.) 5200 w.

†21323. The Principles of Betterment. Hugh H. L. Bellot (W R–April.) 5800 w.

†21325. Our Colonies and Free Trade. A Plea for a Customs Union of the British Empire. W. Peart-Robinson (W R–April.) 4500 w.

Serials.

14653. Theory vs. Practice. W. M. Patton (S–Began July—9 parts to date 30 cts. each).

16290. The Atmosphere as a Medium of Travel. Fred W. Brearey (I & I–Began Sept. 15—10 parts to date—30 cts. each).

16514. The Evolution of Artificial Light. Ill. E. L. Lomax (P A-Began Oct. 16—Ended March 15—9 parts—15 cts. each).

17553. Management of Men and Manufacturing Industries. Thomas D. West (Ir Age-Began Nov. 23—7 parts to date—15 cts. each).

18930. Carnot and Modern Heat. Dr. Oliver Lodge (Eng L-Began Jan. 5—9 parts to date —30 cts. each).

19052. Notes on the Manufacture of Ropes. Ill. W. C. Popplewell (P Eng-Began Jan. 12 —4 parts to date—30 cts. each).

19453. Contributions to the Chemistry of India Rubber. P. Carter Bell (I R W Began Jan. 15—2 parts to date—45 cts. each).

20802. Measurement of High Temperatures. A. Humboldt Sexton (P Eng-Began March 23— 1 part to date—30 cts).

21067. Geological Notes on the Sierra Nevada. H. W. Turner (A G-Began April—1 part to date—45 cts).

THE·TECHNICAL·INDEX

A CATALOGUE OF LEADING ARTICLES PUBLISHED CURRENTLY IN THE TECHNICAL JOURNALS OF THE UNITED STATES AND GREAT BRITAIN.

THIS index has been very properly described as "the greatest step that has been taken in recent years towards systematizing work" for the engineer, the architect, the electrician, the railway manager, and the business man. The list of publications regularly indexed will show that it covers a world-wide range of the best technical literature, and all the articles are so conveniently classified under general headings, that within a few minutes, once a month, an active man can learn of everything of any importance that has been published during the month in relation to the subjects in which he is interested. In short, it is to the practical man just what Poole's celebrated index to periodicals has long been to the literary worker, but with this essential improvement—namely: that in addition to indicating *just when and where* leading articles have been published, *we undertake to supply copies of the articles themselves.* The unparalleled convenience and economy of this double service can readily be appreciated.

IN ordering articles from us, care should be taken to give the *number*, not the title alone. The price of a single article is 15 cents; those indicated by an asterisk (*), 30 cents, and by a dagger (†), 45 cents; and where the cost is above this, the price is given immediately after the number. In every case the price is closely regulated by the cost to us of a single copy of the publication from which the article is taken.

To avoid the inconvenience of small remittances and to cheapen the cost of articles to those who order frequently, we sell coupons at the rate of 15 cents each, or 15 for $2, 40 for $5, and 100 for $12.50. Each coupon is receivable in exchange for one 15-cent article; those marked * require two coupons; those marked † require three coupons; and for the articles of higher price, one coupon for each 15 cents: thus, a 75c. article requires five coupons. Samples of these coupons *will be sent free* for examination. They need only a trial to demonstrate their great convenience and economy.

[In the body of the index only the initials of the journals quoted are given, and these can be readily identified by the following list of periodicals. Other abbreviations are: Ill=Illustrated. w=words.]

THE AMERICAN PRESS.

A	**Arena. *m.*. $5. Boston.**
AA	**American Architect. *w.* $6. Boston.**
Aer	**Aeronautics. *m.* $1. N. Y.**
An A A	**Annals of Am. Academy of Political and Social Science. *b-m.* $6. Philadelphia.**
A An	**American Analyst. *f.* $1. New York.**
A Ar	**American Artisan. *w.* $2. Chicago.**
A & B	**Architecture and Building. *w.* $6. N. Y.**
A B D	**Architect, Builder and Decorator. *m.* $2. Minneapolis.**
A C J	**Am. Chem. Journal. *b-m.* $4. Baltimore.**
A E R J	**Am. Eng. and Railroad Journal. *m.* $3. N.Y.**
A G	**Am. Geologist. *m.* $3.50. Minneapolis.**
A G L J	**Am. Gas Light Journal. *w.* $3. New York.**
A H	**Annals of Hygiene. *m.* $2. Phila.**
A J Phar.	**Am. Journal of Pharmacy. *m.* $3. Phila.**
A J R A	**Jour. R'y. Appliances. *m.* $2. New York.**
A M	**American Machinist. *w.* $3. New York.**
A M & I W.	**Am. Man. and Iron World. $4. Pittsburg.**
Am S	**American Shipbuilder. *w.* $2. New York.**
A & N J	**Army and Navy Journal. *w.* $6. New York.**
A & N R	**Army and Navy Register. *w.* $3. Wash'ton.**
A R	**Architectural Record. *q.* $1. New York.**
A Rev	**Architectural Review. *s-q.* $5. Boston.**
A S	**Age of Steel. *w.* $3. St. Louis.**
B B	**Brick Builder. *m.* $2.50. Boston.**
B C	**Boston Commonwealth. *w.* $2.50. Boston.**
B G S	**Bul. Am. Geog. Soc. *q.* $5. New York.**
B I S	**Bul. Am. Iron and St. Asso. *w.* $4. Phila.**
B J C	**Boston Jour. of Commerce. *w.* $3. Boston.**
B & W.	**Builder and Woodworker. *m.* $3. N. Y.**
C	**Compass. *m.* $1. New York.**
C A	**Calif. Architect. *m.* $3. San Francisco.**
Can A	**Canadian Architect. *m.* $2. Toronto.**
C & B	**Carpentry and Building. *m.* $1. New York.**
C E	**Colliery Engineer. *m.* $2. Scranton, Pa.**
C E N	**Canadian Elec. News. *m.* $1. Toronto.**
C Eng	**Canadian Engineer. *m.* $1. Montreal.**
Ch	**Chautauquan. *m.* $2. Meadville, Pa.**
C M	**Century Magazine. *m.* $4. New York.**
Cos	**Cosmopolitan. *m.* $1.50. New York.**
D E	**Domestic Engineering. *m.* $2. Chicago.**
E A	**Electrical Age. *w.* $3. New York.**
E E	**Electrical Engineering. *m.* $1. Chicago.**
E E N Y	**Electrical Engineer. *w.* $3 New York.**
E I	**Electrical Industries. *m.* $1. Chicago.**
Elek	**Elektron. *m.* $3. Boston.**
E M	**Engineering Mechanics. *m.* $2. Phila.**
E Mag	**Engineering Magazine. *m.* $3. New York.**
E M J	**Eng. and Mining Journal. *w.* $5. N.Y.**
E N	**Engineering News. *w.* $5. New York.**
Eng	**Engineer. *s-m.* $2. New York.**
E N Y	**Electricity. *w.* $2.50. New York.**
E R	**Engineering Record. *w.* $5. New York.**
E R N Y	**Electrical Review. *w.* $3. New York.**
E S W P	**Proc. Eng. So. of W.Pa. *m.* $7. Pittsburg.**
E W	**Electrical World. *w.* $3. New York.**
F	**Forum. *m.* $3. New York.**

F D......The Foundry. *m.* $1. Detroit.
F W .....Fire and Water. *w.* $3. New York.
G & F....Garden and Forest. *w.* $4. New York.
G R......Good Roads. *m.* $1. New York.
I A......Inland Architect. *m.* $5. Chicago.
I Age....Inventive Age. *s-m.* $1. Washington.
Ir Age..Iron Age. *w.* $4.50. New York.
I I G.....Iron Ind. Gazette. *m.* $1.50. Buffalo.
I R W...India Rubber World. *m.* $3. New York.
I S F.....Industry. *m.* $2. San Francisco.
I T R....Iron Trade Review. *w.* $3. Cleveland.
J A C S..Jour. Am. Chem. So. *m.* $5. Easton.
J A E S..Jour. Assoc. Eng. Soc. *m.* $3. Chicago.
J A N E..Jour. Am. Soc. Naval Engineers. *qr.* $5. Washington.
J F I.....Jour. Franklin Institute. *m* $5. Phila
J M S I..Jour. Milit. Service In. *b-m.* $4. NewYork.
J N E W.Jour.N.E.Waterw. As. *q.* $2. New London.
J P E.....Jour. Polit. Economy. *q.* $3. Chicago.
J U S A..Jour. U. S. Artillery. *q.* $2.50. Ft. Monroe.
L E......Locomotive Engineering. *m.* $2. N. Y.
L. H. P..Light, Heat and Power. *m.* $3. Phila.
L Mag...Lippincott's Magazine. *m.* $3. Phila.
M & B...Manufacturer and Builder. *m.* $1.50. N. Y.
Met W...Metal Worker. *w.* $2. N. Y.
M G......Manufacturer's Gazette. *w.* $3. Boston.
Mill......Milling. *m.* $2. Chicago.
Min. R...The Mining Review. *w.* $2. Denver.
M I T....Mining Industry. *w.* $3. Denver.
M R......Manufacturer's Record. *w.* $4. Baltimore.
M R C...Marine Review. *w.* $2. Cleveland, O.
M Rec....The Marine Record. *w.* $2. Cleveland.
M S P....Min. and Sci. Press. *w.* $3. San Francisco.
N A R...North American Review. *m.* $5. N. Y.
N B .....National Builder. *m.* $3. Chicago.
N C B...National Car Builder. *m.* $2. New York.
N P R...Nat. Popular Review. *m.* $2.50. Chicago.
N W.....Nowest. Architect. *m.* $3. Minneapolis.
O P D R..Oil, Paint and Drug Reporter. *w.* $6. N.Y.
P.........Paving. *m.* $2. Indianapolis.
P A......Progressive Age. *s-m.* $3. New York.
P E C P.Procd. Engineer's Club. *q.* $2. Phila.
P S .....Power-Steam. *m.* $1. N. Y.
P S M....Popular Science Monthly. *m.* $5. N. Y.
R A.....Railway Age. *w.* $4. Chicago.
R C J....Railroad Car Journal. *m.* $1. New York.
R E M....Railway Engineering and Mechanics. *m.* $1. Chicago.
R G .....Railroad Gazette. *w.* $4.20. N. Y.
R M.....Roller Mill. *m.* $2. Buffalo, N. Y.
R of R...Review of Reviews. *m.* $2.50. New York.
R R......Railway Review. *w.* $2. Chicago.
R & T...Roofer and Tinner. *m.* $1. N. Y.
S... .....Stone. *m.* $2. Chicago.
S A......Southern Architect. *m.* $2. Atlanta.
San......Sanitarian. *m.* $4. Brooklyn.
Sc........Science. *w.* $3.50. New York.
Sc A ....Scientific American. *w.* $3. New York.
Sc A S ...Scientific Am. Supplement. *w.* $5. N. Y.
Sc M....Scribner's Magazine. *m.* $3. New York.
S E .....Stationary Engineer. *w.* $2. Chicago.
Sc Q.....Scientific Quarterly. *q.* $2. Golden, Cal
Sea......Seaboard. *w.* $2. New York.
S Ec.....Social Economist. *m.* $2. New York.
S J E....Sibley Jour. of Eng. *m.* $2. Ithaca, N. Y.
S M.....ScientificMachinist.*s-m.*$1.50. Cleveland,O.
So L.....Sou. Lumberman. *s-m.* $2. Nashville.
S M Q....School of Mines Quarterly. $2. N. Y.
S R E N..St. R'y. Elec. News. *m.* $2. Minneapolis.
S P......Sanitary Plumber. *s-m.* $1. New York.
S R G....Street Railway Gazette. *w.* $3. Chicago.
S R J....Street Railway Journal. *m.* $4. New York.
S R R.. .Street Railway Review. *m.* $2. Chicago.
S V......Safety Valve. *m.* $1. New York.
T........Tradesman. *s-m.* $2. Chattanooga, Tenn.
T A I E E.Trans. Am. Ins. Elec. Eng. *m.* $5. N. Y.
T C E....Trans. Am. Soc. Civil Eng. *m.* $10. N. Y.
T Q......Technology Quarterly. $3. Boston.
Tr A M E.Trans. Am. Ins. of Mining Eng. N. Y.
T W A .Trans. of the Wis. Acad. Madison.
W E......Western Electrician. *w.* $3. Chicago.

THE FOREIGN PRESS.

A L.....The Architect. *w.* 26*s.* London.
A M S.. Aust. Mining Standard. *w.* 30*s.* Sydney.
A P R...Aus. Pastoralists' Rev. *m.* 20*s.* Sydney.
B A... .The British Architect. *w.* 23*s.* 8*d.* London.
C G.. ..Colliery Guardian. *w.* 27*s.* 6*d.* London.
C R......Contemporary Review. *m.* $4.50. London.
C T J....Chem. Trade Jour. *w.* 12*s.* 6*d.* Manchester.
E.........Engineering. *w.* 36*s.* London.
E E L....Electrical Engineer. *w.* 19*s.* 6*d.* London.
E G......Engineers' Gazette. *m.* 8*s.* London.
E L.......Electricity. *w.* 7*s.* 6*d.* London
El........Electrician. *w.* 24*s.* London.
EngL... Engineer. *w.* 36*s.* London.
E P ......Electrical Plant. *m.* 6*s.* London.
E Rev....Engineering Review. *m.* 7*s.* London.
E R L.....Electrical Review. *w.* 21*s.* 8*d.* London.
F R......Fortnightly Review. *m.* $4.50. London.
G E M...Gas Engrs' Mag. *m.* 6*s.* 6*d.* Birmingham.
G W.....Gas World. *w.* 13*s.* London.
I & I.....Industries and Iron. *w.* £1. London.
I & S.....Iron and Steel Trades' Jour. *w.* 25*s.* London.
I C B... .Carpenter and Builder. *w.* 8*s.* 8*d.* London
I C T.....Iron and Coal Trades. *w.* 30*s.* 4*d.* London.
I E.......Indian Engineering. *w.* 18 Rs. Calcutta.
I Eng....Indian Engineer. *w.* 20 Rs. Calcutta.
Inv .. ..Invention. *w.* 11*s.* London.
I S C.....The Iron, Steel and Coal Times. *w.* £1 6*s.* London.
J G L....Journal of Gas Lighting. *w.* London.
J S A....Journal of the So. of Arts. *w.* London.
M........Machinery. *m.* 9*s.* London.
M E......Marine Engineer. *m.* 7*s.* 6*d.* London.
Min W..The Mining World. *w.* 21*s.* London.
M W.....Mechanical World. *w.* 8*s.* 8*d.* London.
N....... Nature. *w.* $7. London.
N C......Nineteenth Century. *m.* $4.50 London.
P Eng...Practical Engineer. *w.* 10*s.* London.
Pl D .....Plumber and Decor. *m.* 6*s.* 6*d.* London.
R P L....The Railway Press. *m.* 7*s.* London.
R W.....Railway World. *m.* 5*s.* London.
S L......Steamship. *m* Leith, Scotland.
S R......Sanitary Record. *m.* 10*s.* London.
Tr.......Transport. *w.* £1. 5*s.* London.
W R.....Westminster Review. *m.* $4.50. London.

ARCHITECTURE.

*21163. American Architecture through English Spectacles. Banister F. Fletcher (E Mag–June.) 3000 w.

*21204. Feathers in Decoration. Ill. H. Leslie Ramsey (Pl D–April 2.) 1200 w.

*21205. The Durability of Paint. Arthur Seymour Jennings (Pl D–April 2.) 700 w.

*21237. The Architect of Fashion. Leopold Eidlitz (A R–April-June.) 5300 w.

*21241. Architectural Aberrations. — The New Criminal Court Building, New York. Ill. (A R–April-June.) 1600 w.

†21243. Women as Students in Design. Mrs. J. E. H. Gordon (F R–April.) 3200 w.

21248. The Forests of the South (T–April 15.) 800 w.

*21303. The Poetry of Light. P. Morley Horder (B A–April 6.) 1100 w.

*21304. The Arbitration Clause in America (A L–April 6.) 2000 w.

*21307. Facade of the German Reichstag Building, Berlin. Ill. (I C B–April 6.) 1100 w.

†21403. All Saints' Cathedral, Allahabad. (I E–March 17.) 600 w.

21427. Our Senators and Our Public Buildings.—Discussion in the Senate on April 11 (A A–April 21.) 5000 w.

*21449. Bronze Doors. Ill. (A L–April 13.) 2200 w.

*21451. Italian Building Societies. Geoffrey Drage (A L–April 13.) 3800 w.

*21452. Architecture and Its Civic and Commercial Value. Banister F. Fletcher (A L–April 13.) 4000 w.

*21453. The Assessor in America. N. S. Patton (A L–April 13.) 5600 w.

†21463. Consideration of the Correspondence Relative to the Tarsney Bill (I A–April.) 1500 w.

*21482. Growth of Gothic Architecture. T. Perkins (I C B-April 13.) 1200 w.

*21484. Carving. Ill. (I C B–April 13.) 1100 w.

*21485. Some Points on Building. Joseph Power (I C B–April 13.) 800 w.

21515. The Wuensch and Melan Systems of Fire-proof Floor Construction. Ill. (E N–April 12.) 1100 w.

†21556. The New Building Law of the City of Philadelphia. Frederick H. Lewis, with Discussion (P E C P–Jan.-March.) 6000 w.

21587. Progressive Architecture. Editorial (A & B–April 28.) 700 w.

*21599. The Architecture of the Renaissance in England.—Review of Book by J. A. Gotch, assisted by W. Talbot Brown (B A–April 20.) 800 w.

*21600. Bases of a Successful Architectural Practice in the Twentieth Century. W. Howard Seth-Smith (B A–April 20.) 3300.

*21616. English and American Fireplaces (I C B–April 20.) 1200 w.

*21621. Styleless Architecture (A L–April 20.) 2400 w.

*21659. American Art in Stained Glass and the Influence of the Great Fairs thereon. William A. Hazel (A B D–April.) 2400 w.

*21660. The Workman and the Architect. (Abstract.) Owen Fleming (A B D–April.) 1350 w.

21702. A Great Barn.—L. P. Morton's Stock Farm (Sc A S–May 5.) 3000 w.

*21735. A Terra-Cotta Residence. Ill. D. Everett Waid (B B–April.) 1200 w.

*21738. The Roof in Fire-proof Construction. John R. Elder (B B–April.) 1400 w.

*21785. Report of the Amalgamated Society of Carpenters and Joiners (I C B–April 27.) 2800 w.

21892.—$1.50. The Tower of the New City Hall at Philadelphia, Pa. Ill. C. R. Grimm, with Discussion (T C E–March.) 10700 w.

Serials.

7121. Office-Helps for Architects. George Hill (A A–Began Oct. 8, 1892—28 parts to date —15 cts. each).

7421. French Cathedrals. Barr Ferree (A R–Began Oct.-Dec.—4 parts to date—30 cts. each).

12568. Building Construction and Superintendence. F. E. Kidder (A & B–Began May 6, 1893—24 parts to date—15 cts. each).

13358. Modern Asylums for the Insane. Ill. George H. Bibby (A A–Began June 3—Ended May 5—9 parts—15 cts. each).

14370. Wasted Opportunities.—Defects of Office Buildings (A R–Began July-Sept.—3 parts to date—30 cts. each).

16576. Architects' Houses. Ill. John Beverley Robinson (A R–Began Oct.-Dec.—3 parts to date—30 cts. each).

18214. The École des Beaux-Arts. Ill. Ernest Flagg (A R–Began Jan.-March—2 parts to date—30 cts. each).

18857. Electrical Science for Architects. Russell Robb (A A–Began Jan. 13—4 parts to date—15 cts. each).

19345. The French Renaissance. Ill. Anthyme Saint-Paul (A A–Began Feb. 3—6 parts to date—15 cts. each).

19713. Brick and Marble in the Middle Ages. Ill. (B B–Began Jan—4 parts to date—30 cts. each).

19749. Lead Light and Stained Glass Glazing. Jehan Le Vitrier (Pl D–Began Feb.— 3 parts to date—30 cts. each).

20419. Modern Methods of House Painting. A. Ashmun Kelly (Pl D–Began March—2 parts to date—30 cts. each).

21131. Roofs. Ill. George H. Blagrove (I C B–Began March 30—5 parts to date—30 cts. each).

21195. A Glimpse of Modern Greece. Ill. Thomas A. Fox (A Rev–Began Aug. 14—1 part to date—75 cts).

21288. Theatres. Ill. (A A–Began April 14—1 part to date—15 cts).

21431. The Harmony and Functions of Color in Art. Andrew T. Taylor (Can A—Began April—1 part to date—30 cts).

21464. Henry Van Brunt, Architect, Writer and Philosopher. P. B. Wight (I A—Began April—1 part to date—45 cts).

21588. The Practice and Ethics of Architecture. George C. Mason, Jr. (A & B–Began April 28—1 part to date—15 cts).

21618. Bay Windows and Oriels. F. Jerman (I C B–Began April 20—1 part to date—30 cts).

21638. Style. Leon Labrouste (A A–Began April 28—2 parts to date—15 cts. each).

21639. The Italian Renaissance (A A–Began April 28—2 parts to date—15 cts. each).

21736. The Art of Building Among the Romans. Auguste Choisy (B B–Began April—1 part to date—30 cts).

21781. Some of the Principles of Sanitary Building. H. H. Collins (A L–Began April 27—1 part to date—30 cts).

CIVIL ENGINEERING.

*21157. Breakwaters, Sea-walls and Jetties. Ill. George Y. Wisner (E Mag–June.) 3000 w.

*21164. Cement and Cement-Testing. Spencer B. Newberry (E Mag–June.) 4000 w.

21217. Nicaragua Canal.—Its Importance to the United States and Reasons why this Government Should Control It. Ill. M. H. Moore (I Age–April.) 2500 w.

21278. Rock Dredging in the Raritan River (E R–April 14.) 1600 w.

21332. Improved Arches for Culverts. Ill. (R R–April 14.) 600 w.

21357. Cement Testing. Spencer B. Newberry (Sc A S–April 21.) 5000 w.

21376. Pile-Driving by Water Jet, Interstate Bridge, Omaha, Neb. Ill. (E N–April 19.) 800 w.

*21432. Notes on Recent Additions to Our Knowledge of Portland Cement. John Purser Griffith (Can A–April.) 2900 w.

*21438. Macadamized Road Scarifier Trials (E–April 13.) 2500 w.

*21442. Machinery as Applied to the Breaking up of Macadam. Ill. Arthur E. Collins (E–April 13.) 4500 w.

*21454. Harbor and River Improvement in the United States (Tr–April 13.) 2000 w.

*21456. The Bilbao Harbor Works (Abstract). William Kidd (I C T–April 13.) 2000 w.

*21470. The Panama Canal as It Is. Ill. (Eng L–April 13.) 1500 w.

21507. Country Roads (Abstract). A. W. Campbell (E R–April 21.) 1000 w.

21511. The Minnesota Canal. Allan Ross Davis (E N–April 12.) 1400 w.

21512. Foundations of the Cheat River Bridge, Baltimore and Ohio Railroad. Ill. Cecil B. Smith (E N–April 12.) 1500 w.

21528. The Nicaragua Canal.—Review of Senator Morgan's Report, with Editorial (Sea–April 26.) 6000 w.

21543. The Compressed Asphalt Block as a Pavement for Cities and Large Towns. Ill. (G R–April.) 1300 w.

†21554. The New Falls of Schuylkill Bridge of the Philadelphia and Reading Railroad Company. Ill. W. B. Riegner, with Discussion (P E C P–Jan.–March.) 2200 w.

†21555. Comments on Current Practice in the Designing of Plate Girders. Edgar Marburg, with Discussion (P E C P–Jan.–March.) 5300 w.

21570. Harper's Ferry Improvements (R G–April 27.) 2000 w.

21590. Erection of the Florence Bridge. Ill. (E R–April 28.) 1500 w.

*21708. Physical Properties of Asphalts. Dolphus Torrey (P–May.) 900 w.

*21709. Capt. Torrey's Reply to Prof. De Smedt. Dolphus Torrey (P–May.) 1700 w.

*21712. The Value of Good Roads. Evans Woollen (P–May.) 4400 w.

21719. The Reported Shoal at the Mississippi Jetties (E N–May 3.) 1200 w.

*21739. American Portland Cement. William J. Donaldson (B B–April.) 3500 w.

21813. Pittsburg's Ship Canal Project (I T R–May 3.) 500 w.

*21815. How to Make and Lay Floors, Roads and Paths (N B–May.) 1000 w.

21880. The Park Avenue Improvement in New York City.—The Temporary Harlem River Bridge and the Moving of the Mott Haven Station. Ill. (Sc A–May 12.) 1100 w.

21893.—$1.50. The Removal of a Defective Pivot Pier, and Its Reconstruction. Ill. Howard G. Kelley (T C E–March.) 6000 w.

21894.—$1.50. Lining a Water-Works Tunnel with Concrete. Ill. Desmond FitzGerald, with Discussion (T C E–March.) 15000 w.

Serials.

16520. Plant and Gear Locally Made for the Kistna Bridge. Ill. F. J. E. Spring (I E–Began Sept. 9—10 parts to date—45 cts. each).

19649. Beams of Uniform Strength. William White Robertson (I E–Began Jan. 6—5 parts to date—45 cts. each).

20688. Hudson County Boulevard (E R–Began March 24—2 parts to date—15 cts each).

21592 The Harlem River Speedway. Ill. (E R–Began April 28—1 part to date—15 cts).

ELECTRIC LIGHTING.

21176. Grounds in Incandescent Circuits. George L. Thayer (E E N Y–April 11.) 800 w.

*21289. The Origin of Electric Incandescent Lighting.—Statement by Hiram S. Maxim (I & I–April 6.) 1300 w.

21509. The Cost of Street Lighting with Arc Lamps (E N–April 12.) 1500 w.

21516. On the Deposition of Carbon in Incandescent Lamps. Ill. E. A. Colby (E R N Y–April 25.) 500 w.

21531. Small Arcs or Large Incandescents? Albert Scheible (E E N Y–April 25.) 850 w.

*21539. Electric Light in Domestic Economy. Forée Bain (S R E N–April.) 650 w.

21589. Electric Lighting of the New Chicago Tunnel. Ill. (W E–April 28.) 900 w.

*21609. The Electric Light in an Explosive Atmosphere. Alfred H. Gibbings (E L–April 20) 1300 w.

*21612. The Rollason Wind Motor. Ill. (El–April 20.) 600 w.

*21265. Windmills and the Rollason Improved Wind Motor. Editorial (Inv–April 21.) 2400 w.

*21627. Adjourned Discusssion of paper by John H. Rider entitled " Notes on Designing a System of Underground Mains," and of paper by S. V. Clirehugh, on "The Various Systems of Underground Mains and Methods of Laying Same (E E L–April 20.) 4400 w.

*21629. Electrical Communication with Lightships. Editorial (P Eng–April 20.) 800 w.

21663. Testing for Grounds on Incandescent Circuits. Ill. Austin S. Hatch (E E N Y–May 2.) 800 w.

21723. The Cost of Street Lighting with Arc Lamps. Editorial (E N–May 3.) 1800 w.

*21835. The Dundee Central Electric Light Station. Ill. (E E L–April 27.) 2800 w.

21852. The Age Coating of Incandescent Lamps. Elihu Thomson (E R N Y–May 9.) 1000 w.

21853. Electric Lighting Plant of the " Priscilla." Ill. (E R N Y–May 9.) 600 w.

21855. The Eaton Arc Dynamo and Lamps. T. F. Pickett (C E N–May.) 2000 w.

*21874. Electricity as a Source of Light (J G L–May 1.) 1700 w.

21896.—$1.50. The Electric Station of the Citizen's Light and Power Company of Rochester, N. Y. Ill. Robert Cartwright, with Discussion (T C E–March.) 7500 w.

Serials.

13548. Arc Lighting. Ill. E. Tremlett Carter (E R L–Began June 2, 1893—14 parts to date—30 cts. each).

21119. South Boston Electric Light Station. George H. Barnes (E R–Began April 7—2 parts to date—15 cts. each).

21169. Electric Lighting. F. B. Crocker (E R N Y–Began April 11—Ended April 25—3 parts—15 cts. each).

21476. Present Conditions of Installing Electric Mains in the Premises of Consumers Supplied from Central Stations (E R L–Began April 13—1 part to date—30 cts).

ELECTRIC MISCELLANY.

21173. The Advisability of Becoming an Electrical Engineer. Henry Floy (E W–April 14.) 2800 w.

21174. Electrical Legislation in New York (E W–April 14) 1200 w.

21175. Nikola Tesla and His Work. F. Jarvis Patten (E W–April 14.) 2800 w.

21179. A Universal Shunt Box for Galvanometers. Ill. W. E. Ayrton and T. Mather (E E N Y–April 11.) 1300 w.

21254. A Good Electric Ground. Charles Desmond (S R G–April 14.) 1400 w.

*21256. Magnetic Qualities of Iron. Rollo Appleyard (E R L–April 6.) 1700 w.

*21257. The Electrification of Gases and Liquids. J. E. Taylor (E R L–April 6.) 1600 w.

†21326. Destructive Effect of Electrical Currents on Subterranean Metal Pipes. Ill. Isaiah H. Farnham (T A I E E–April.) 4300 w.

21354. The General Electric Wreck.—The Present Condition—The Cause—The Outlook—The Responsibility (E N Y–April 18.) 2700 w.

21395. Battery " Fakes." C. M. W. (E A–April 21.) 1300 w.

*21475. The Law of Hysteresis (E R L–April 13.) 600 w.

*21477. Graphical Treatment of Alternate Current Conductors in Parallel. Ill. E. C. Rimington (E R L–April 13.) 900 w.

21532. Storage Battery Testing. Robert McA. Lloyd (E E N Y–April 25.) 1200 w.

21537. Remarkable Applications of Electricity. From Chambers' Journal (Sc A–April 28.) 2200 w.

*21613. The Astatic Station Voltmeter. Ill. W. E. Ayrton and T. Mather (El–April 20.) 1400 w.

*21614. Transparent Conducting Screens for Electric and Other Apparatus. W. E. Ayrton and T. Mather, with Discussion. (El–April 20.) 2800 w.

*21632. The Best Frequency for Alternating Installations. Ill. (E R L–April 20.) 1700 w.

*21633. Cost Price of Electrical Energy in Central Stations. J. Laffargue (L'Industrie Electrique) (E R L–April 20.) 1100 w.

21664. Connecting Field Magnets to Bus Bars. Ill. C. S. Van Nuis (E E N Y–May 2.) 800 w.

21821. The Genesis of the Thunderstorm. William N. Page (E M J–May 5.) 2200 w,

*21834. A System of Nomenclature for Decimal Multiples and Sub-Multiples. (R. B. Hayward (E E L–April 27.) 700 w.

Serials.

20885. On Cathode Rays in Gases Under Atmospheric Pressure and in Extreme Vacua. Philipp Lenard (El–Began March 23—Ended April 6—3 parts—30 cts. each).

21172. Unipolar Induction and Current without Difference of Potential. Ill. A. G. Webster (E W–Began April 14—2 parts to date —15 cts. each).

21266. Magnetic Qualities of Iron. Ill. J. A. Ewing and Helen G. Klaassen (El–Began April 6—3 parts to date—30 cts. each).

21396. Coming Developments in Electricity. George D. Shepardson (E A–Began April 21—1 part to date—15 cts).

21697. The Cost of Producing Electricity. J. B. Cahoon (E W-Began May 5—2 parts to date—15 cts. each).

21744. Electrical Oscillations. Newton Harrison (E A-Began May 5—1 part to date—15 cts).

21777. Cost of Electrical Energy. R. E. Crompton (El-Began April 27—1 part to date—30 cts.).

ELECTRIC POWER.

*21156. The Electric Transmission of Power. F. B. Crocker (E Mag-June.) 3000 w.

21180. The Canal Contract.—Full Text of the Agreement (E N Y-April 11.) 2000 w.

21221. Electric Power in Mills and Factories (M G-April 14.) 1500 w.

21272. Electricity on the Canals (P A-April 16. 1300 w.

*21294. Electric Transmission of Power from the Periyar River, Southern India (Eng L-April 6.) 2800 w.

21336. Sprague-Pratt Electric Elevators.—The Postal Telegraph Plant in the New Broadway Building. Ill. (E R N Y-April 18.) 4800 w.

21356. Storage Battery Lighting and Car Propulsion (Sc A-April 21.) 1250 w.

21370. Electric Transmission of Power in Chicago.—Factories of the Western Electric Company. Ill. (W E-April 21.) 1400 w.

*21423. Portable Electricity. John Trowbridge (Ch-May.) 3000 w.

*21457. The Electric Power Plant at Dumbreck Colliery, Kilsyth. James T. Forgie (I C T-April 13.) 3600 w.

*21459. Electric Power Station at the Decize Colliery, Saone et-Loire, France. M. C. Walckenaer (C G-April 13.) 1700 w.

*21495. Power Transmission by Means of High Pressure Direct Currents. E. Schulz (El-April 13.) 800 w.

*21646. Electric Power Installations in Engineering and Iron Works. D. Selby-Bigge. (C G-April 20.) 1400 w.

21661. An Estimate of the Distance to Which Niagara Water Power Can Be Economically Transmitted by Electricity. Edwin J. Houston and A. E. Kennelly, with Editorial. (E E N Y-May 2.) 3000 w.

21686. Textile Manufacturing by Electric Power—Taftville, Conn. Ill. (E R N Y-May 2.) 1400 w.

21687. Chicago's Electric Department. Fred De Land. (E R N Y-May 2.) 800 w.

†21761. The Electric Motor. F. B. Crocker. (J F I-May.) 3200 w.

*21771. Editorial on Professor Kennedy's Address to the Mechanical Engineers. (E R L-April 27.) 1800 w.

*21772. I. Regulation and Governing of Electromotors. Editorial. II. A New System of Regulating Motors—H. Ward Leonard's. Ill. (E R L-April 27.) 3500 w.

*21812. Electrical Transmission of Power at the Masse-Diarbois Colliery, Ransart. Ill. Emile Gosseries. (C G-April 27.) 2000 w.

Serials

9858. The Calculation of Alternating Current Motors. Ill. E. Arnold (E W-Began Jan. 21, 1893—9 parts to date—15 cts. each).

11560. Electric Motor Power. Ill. Albion T. Snell (El-Began March 17, 1893—16 parts to date—30 cts. each).

21698. The Practical Importance of Resonance in the Transmission of Electrical Power. F. W. Dunbar (E W-Began May 5—2 parts to date—15 cts. each).

21776. Professor A. B. W. Kennedy's Presidential Address to the Institution of Mechanical Engineers (El-Began April 27—1 part to date—30 cts).

GAS ENGINEERING.

*21211. The Construction of Gasholders. (Abstract.) E. Lloyd Pease (J G L-April 3.) 3800 w.

21270. Gas Companies and the Public. W. C. Boyle, with Discussion (A G L J-April 16.) 6000 w.

21271. The Joint Business of Gas and Electric Light. Howard Jones, with Discussion (A G L J-April 16.) 10500 w.

21273. Gas for Fuel. Donald M'Donald, with Discussion (P A-April 16.) 6500 w.

*21275. A Great Gas Corporation from an Investment Point of View (L H P-April.) 1800 w.

*21276. Improvement in Scrubbing, Purifying and Condensing Gas. Ill. (L H P-April.) 1000 w.

*21284. Photometry. (Abstract.) W. de W. Abney (E-April 6.) 2000 w.

*21400. The Construction of Gas Works. (Abstract.) Charles Hunt (J G L-April 10.) 2000 w.

*21401. The Construction of Gasholders.—Discussion of Paper by E. Lloyd Pease (J G L-April 10.) 6500 w.

*21430. London Coal-Gas and Its Enrichment. Vivian B. Lewes, with Discussion. (J S A-April 13.) 9200 w.

*21440. Photometry. (Abstract of 2d Lecture.) W. de W. Abney (E-April 13.) 1500 w.

*21458. The Pressure and Expansion of Gases and Steam. (A J R A-April.) 800 w.

*21546. A Visit to the Lancaster Gasworks (G E M-April 10.) 2800 w.

*21547. Protecting Gas Pipes. (G E M-April 10.) 1800 w.

*21636. Inaugural Address of Norton H. Humphrys (G W-April 21.) 6800 w.

*21637. Inaugural Address of W. J. Carpenter (G W-April 21.) 3700 w.

*21644. Photometry. (Abstract of 3d and Last Lecture.) W. de W. Abney (E-April 20.) 2000 w.

21654. Water Fuel Gas.—The Peters Patent. Ill. (A M & I W-April 27.) 1600 w.

*21758. The Prepayment Meter System. G. J. Gough (J G L-April 24.) 1200 w.

*21795. The Sacrifice of Heat in Making

Producer Gas. James Ormiston (I C T–April 27.) 3000 w.

*21796. Notes on the Efficiency of Gaseous Fuel. F. A. Matthewman (I C T–April 27.) 2000 w.

*21809. Public Waste in Gas Consumption. Vivian B. Lewes (B A–April 27.) 900 w.

*21829. Retorts and Chimneys. A. Thomas, with Discussion (G W–April 28.) 3300 w.

Serials.

19815. Gas for the Household. William Paul Gerhard (D E–Began Feb.—3 parts to date—30 cts. each).

20417. Gas Stoves and Ventilation. Edward J. Smith (Pl D–Began March—2 parts to date—30 cts. each.

21052. The Development of the Gasholder. A. M'I. Cleland (J G L–Began March 27—2 parts to date—30 cts. each).

21760. On Gas Burners, Gas Pressure Regulators and Governor Burners, Gas Globes and Globe Holders, and Gas Fixtures. William Paul Gerhard (J F I–Began May—1 part to date—45 cts.

21887. Testing Gas Engines. Ill. (M W–Began May 4—1 part to date—30 cts).

HYDRAULICS.

*21347. The Cumberland (Q.) Dam Disaster (A M S–March 10.) 1300 w.

21378. Proposed Supplementary Water Supply for Duluth, Minn. W. H. Hoyt (E N–April 19.) 700 w.

21380. Sewall Falls Dam Across the Merrimac River near Concord, N. H. Ill. Daniel Ulrich (E N–April 19.) 1400 w.

21397. Burlington's (Ia.) New Filter System (F W–April 21.) 900 w.

21418.—$1.50. The Water Works of Denver, Col., with Discussion. Ill. James D. Schuyler (T C E–Feb.) 16000 w.

21506. The Electrolysis of Water Pipes (E R–April 21.) 3000 w.

*21522. Irrigation from the Yellowstone River. Charles Tappan (J A E S–Feb.) 2000 w.

*21523. Water Power—Its Measurement and Value. George A. Kimball, with Discussion (J A E S–Feb.) 6500 w.

21567. The Niagara Falls Paper Company's Power Plant. Ashley B. Tower (E N–April 26.) 1600 w.

*21643. The Assouan Dams on the Nile. Ill. (E–April 20.) 1500 w.

*21648. The Application of Hydraulic Machinery to the Manchester Trade. (Abstract.) Gilbert Lewis (C G–April 20.) 1200 w.

21656. The Venturi Meter (M G–April 28.) 1300 w.

*21681. Hydraulic Boat Lifts. Ill. G. Braet (A E R J–May.) 1800 w.

*21799. San Roque Dam, Argentine Republic. Ill. (Eng L–April 27.) 1800 w.

21826. Pumps and Pumping. William Perry (C Eng–May.) 2800 w.

21898.—$1.50. Driven Wells of the Plainfield Water Supply System. L. L. Tribus, with Discussion (T C E–March.) 8000 w.

Serials.

18676. The Pumping Engine: Its Many Points, Faults and Peculiarities. Ernest W. Naylor (F W–Began Jan. 6—12 parts to date—15 cts. each).

18801. Discharge of Sluices and Weirs Under Varying Heads. G. C. Maconchy (I E–Began Dec. 9—10 parts to date—45 cts. each).

20808. Ahmedabad Water Works Report. Ill. (I E–Began Feb. 24—4 parts to date—45 cts. each).

21015. Stand Pipe Accidents and Failures. Ill. William D. Pence (E N–Began April 5—5 parts to date—15 cts. each).

21021. The Missouri River. (Extracts.) O. B. Gunn (R G–Began April 6—2 parts to date—15 cts. each).

21311. Water Power at Worcester (I C B–Began April 6—2 parts to date—30 cts. each).

21405. The Coefficients of Discharge of the Kistna Anicut. Ill. Alfred Chatterton (I E–Began March 17—3 parts to date—45 cts. each).

21433. Glasgow Water Works. Ill. (E–Began April 13—2 parts to date—30 cts. each).

21551. Application of Hydraulic Machinery to the Manchester Trade. Gilbert Lewis (M W–Began April 20—2 parts to date—30 cts. each).

INDUSTRIAL CHEMISTRY.

*21291. The Chemical Industry of the United States (I & I–April 6) 1600 w.

*21301. Ira Remsen on Chemical Laboratories—Address delivered at the opening of the Kent Chemical Laboratory, Chicago (N–April 5.) 5800 w.

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21563. The Train Staff and Tablet Systems for High Speed Train Service. Ill. (E N–April 26.) 2200 w.

21565. Track Elevation, Lake Shore and Rock Island Railways, Chicago (E N–April 26.) 1000 w.

21566. Accidents to Postal Cars (E N–April 26.) 1800 w.

21568. Handling Air-Braked Trains (R G–April 27.) 3500 w.

21569. The Relation of Wheels to Frog Points and to Guard Rails. (Abstract.) Archibald A. Schenck (R G–April 27.) 2000 w.

21571. The Use of Small Anthracite for the Prevention of Smoke. Editorial (R G–April 27.) 1200 w.

21572. Another Central African Railroad (R G–April 27.) 1200 w.

21573. How to Instruct Trainmen and Inspectors about Air-Brakes. F. M. Nellis (R G–April 27.) 4300 w.

21594. The Decision in the Northern Pacific Strike Cases, with Editorial (E M J–April 28.) 2800 w.

*21642. The International Railway Congress. Editorial (E–April 20.) 1700 w.

*21650. The Great Northern Lines in Yorkshire. Ill. (Eng L–April 20.) 800 w.

*21651. Train Resistances.—English and American. Editorial (Eng L–April 20.) 1600 w.

21658. The Immigrant Rate War. Editorial (R A–April 27.) 550 w.

†21667. A Revolutionary Railway Company. Albert Griffin (A–May.) 3500 w.

21670. Four-Cylinder Compound Locomotives of the Hungarian State Railway. Ill. (R R–April 28.) 2500 w.

21671. Which Policy Best for State Railroad Commissions—Arbitrary or Advisory? (R R–April 28.) 2500 w.

21672. Air-Pump Repairs. Otto Best and C. A. Sanders (R R–April 28.) 2300 w.

*21683. Uneven Performance of Locomotives. Editorial (L E–May.) 2000 w.

*21684. A Bit of Railroad Geometry. John H. Cooper (L E–May.) 1500 w.

*21685. Air-Brake Peculiarities. Will W. Wood (L E–May.) 1800 w.

*21688. Care of Passenger Trains at Terminals. E. A. Williams (N C B–May.) 1300 w.

*21689. Locomotive Boiler Tubes.—Removing Tubes and Scale. Ill. James F. Hobart (N C B–May.) 1200 w.

21721. The Efficiency of Air and Foundation Brakes. Waldo H. Marshall (E N–May 3.) 3000 w.

21722. Tests of Punches of Different Forms. Ill. George S. Allen (E N-May 3.) 1800 w.

21732. The Design and Material for Driving Boxes (R E M–May.) 1000 w.

21740. Short or Long Smoke-boxes.—Letters and Editorial. Ill. (R G–May 4.) 4000 w.

21741. Cleaning and Oiling Triple Valves and Brake Cylinders.—Report of Air-Brakemen's Convention (R G–May 4.) 2700 w.

21742. The Progress of Railroad Reorganization. Editorial (R G–May 4.) 1700 w.

*21748. Corliss Valves on Locomotives. Ill. (M W–April 27.) 1400 w.

*21750. Rail Fastenings for Metal Sleepers. Herr Banovit's System. Ill. (E Rev–April 20.) 1500 w.

21768. Hygienic Conditions Necessary for the Transportation of Persons Ill with Infectious and Contagious Diseases. G. P. Conn, with Editorial (R A–May 4.) 5300 w.

21769. A Great Railway Museum. The Permanent Collection of Transportation Appliances and Curiosities at Jackson Park. Ill. (R A–May 4.) 1200 w.

21770. Rules of Interchange—Recommendations of Central Railway Club (R A–May 4.) 1800 w.

21824. Elevated Railroad Water Pipes and Frost Protection System in Chicago. Ill. (E R–May 5.) 1400 w.

21828. Chicago and St. Louis Electric Railroad. Ill. (S R G–May 5.) 1300 w.

21832. Railroad Names. John T. Bramhall (R R–May 5.) 1800 w.

21833. A Point Gained for Shippers. Editorial (A S–May 5.) 800 w.

21850. Maintenance and Repair of Air-Brakes. Elmer E. Chain (R C J–May.) 1800 w.

21881. The Bicycle Upon Rails. Ill. (Sc A–May 12.) 700 w.

21882. The Tubular Railway of Paris. Ill. (Sc A S–May 12.) 1300 w.

21895.—$1.50. Spirals and Their Use on Railroads. A. S. C. Würtele (T C E–March.) 1800 w.

21897.—$1.50. The Renewal of the Channel Pier of the Cincinnati and Muskingum Valley Railway Bridge over the Scioto River. Ill. Morton L. Byers, with Discussion (T C E–March) 3000 w.

Serials.

9254. Railway Management. Horace Cope (R R–Began Dec. 31, 1892—12 parts to date—15 cts. each).

12001. Rails on the Creep. A. Ewbank (I E–Began March 11, 1893—45 parts to date—45 cts. each).

17826. Evolution of the Air Brake. Paul Synnesvedt (R E M–Began Dec.—6 parts to date—15 cts. each).

18225. Experiences of a Superintendent. C.

P. Young (S R R–Began Dec.—4 parts to date —30 cts. each).

18435. Painting a Railway Passenger Car. A. Ashmun Kelly (R E M–Began Jan.—4 parts to date—15 cts. each).

18957. Ventilation of Passenger Cars. Ill. James F. Hobart (R C J–Began Jan.—Ended May—5 parts—15 cts. each).

20611. The Mont Salève (Geneva) Electric Rack Railway. Ill. C. S. Du Riche Preller (E–Began March 9—Ended April 20—4 parts—30 cts. each).

20892. Signal Apparatus in Use on the Grand Central Railway of Belgium. Ill. Leopold Kirsch (A E R J–Began April—2 parts to date —30 cts. each).

21498. Bills of Lading. Viator (R R–Began April 21—3 parts to date—15 cts. each).

21679. The Reciprocating Parts of a Locomotive. Ill. F. J. Cole (A E R J–Began May —1 part to date—30 cts.)

STREET RAILWAYS.

21167. The Brand Conduit Railway System. Ill. (E R N Y–April 11.) 500 w.

21222. Electrical Signal System for Cable Railways. Ill. (E A–April 14.) 1200 w.

21223. Electrically Operated Elevated Railroad Bridge. Ill. (W E–April 14.) 800 w.

*21265. Light Electric Railways. Editorial (El–April 6.) 1650 w.

21383. New Tunnel of the West Chicago Street Railway Company. Ill. R G–April 20.) 900 w.

*21388. Electrics in the Crescent City. Ill. (S R R–April 15.) 3800 w.

*21392. An Important Interurban.—Johnstown, Gloversville and Fonda. Ill. (S R R–April 15.) 1200 w.

*21480. Electric Traction. E. F. Bamber (N–April 12.) 2000 w.

21520. Suggestions for Transit Systems. Ill. S. D. Mott (E W–April 28.) 600 w.

21545. Cities and Street Railroad Companies —Their Mutual Relations. Ill. H. H. Carter (G R–April) 3000 w.

*21628. Mechanical Tramway Traction: Compressed Air or Electricity. Ill. Victor Popp (E E L–April 20.) 4000 w.

*21690. Madras Electric Railway Begun. Ill. (S R R–March 15.) 800 w.

*21691. A Graphic Method of Superintendency (S R R–March 15.) 1000 w.

*21692. Long Distance Transmission by Continuous Currents. Ill. F. Boissonnas (S R R–March 15.) 1800 w.

*21693. Performance of Modern Motor Equipments (S R R–March 15.) 1000 w.

*21694. Electricity in Anaconda, Montana. Ill. (S R R–March 15.) 900 w.

*21695. Rapid Transit in New York.—A Solution of the Problem.—The Moving Sidewalk. Ill. (S R R–March 15.) 500 w.

21700. The Luhrig Gas Motor Car. Ill. (Sc A S–May 5.) 1500 w.

21724. Present Utility of Electric Motors on Railways. David L. Barnes (E N–May 3.) 3800 w.

†21726. The Isle of Man Tramways. Ill. (S R J–May.) 1500 w.

†21728. New Orleans, Galveston and Houston. Ill. (S R J–May.) 11500 w.

21730. Novel Construction for an Elevated Electric Railroad.—Tunneling Through Buildings. Ill. (W E–May 5.) 700 w.

*21746. The Genoa Electric Tramways. Ill. (R W–April.) 1500 w.

21851. The Overhead Trolley in New York City.—Completion of the One-Hundred-and-Thirty-fifth Street Line. Ill. (E R N Y–May 9.) 800 w.

Serials.

18549. The Intrinsic Value of Street Railway Investments. Edward E. Higgins (S R J–Began Jan.—5 parts to date—45 cts. each).

18711. Electric Railway Motors: Their Construction and Operation. Nelson W. Perry (S R G–Began Jan. 6—17 parts to date—15 cts. each).

21260. Electric Traction. C. H. Wilkinson (E P–Began April—1 part to date—30 cts).

21747. Steam Tramway Locomotives. Ill. H. Conradi (R W–Began April—1 part to date —30 cts).

21870. A Steam Tramway as a Feeder Line. C. B. Target (I E–Began April 7—1 part to date —45 cts).

SANITARY ENGINEERING.

*21200. Sanitation in Paris. (Pl D–April 2.) 1400 w.

*21306. Technical Museums and Sanitation. De Courcy Meade (A L–April 6.) 3500 w.

21379. Lessons from the Typhoid Epidemic at Montclair, N. J. (E N–April 19.) 1500 w.

21398. Novel Sewer Experiment. Hubert Heywood (F W–April 21.) 1300 w.

*21416. The Plumber's Essay. John Troland (D E–April.) 2800 w.

*21417. Sanitation in the House. Robert Morgan (D E–April.) 2000 w.

*21478. A City's Health and How It Is Preserved. Peter Fyfe (S R–April 14.) 8200 w.

*21479. Prof. V. Babes on the Position of the State in Respect to Modern Bacteriological Research. (N–April 12.) 5000 w.

*21524. Sewage Disposal Works, Canton, O. Ill. (J A E S–Feb.) L. E. Chapin.

†21525. A National Health Bureau. George M. Sternberg (N A R–May.) 1800 w.

*21552. Restriction and Prevention of Dangerous Communicable Diseases from the Standpoint of the Health Officer and Physician. Frank M. Gier (A H–May.) 2200 w.

*21619. Roman Baths (I C B–April 20.) 1500 w.

*21620. Simple Sanitation (I C B–April 20.) 950 w.

*21635. Scavenging and Disposal of Refuse. Charles Mason (S R–April 21.) 5000 w.

*21711. Methods of Sewer Construction, Watertown, N. Y. Ill. Fred E. Avery (P–May.) 1000 w.

21756. The Self Purification of Rivers. Charles V. Chapin (S C–March 23.) 1600 w.

*21773. Electrical Sanitation. Ill. (E R L –April 27.) 3500 w.

*21804. Sanitation in India. Editorial. (E –April 27.) 3000 w.

*21807. The Heating and Ventilation of the Houses of Parliament. (B A–April 27.) 1500 w.

Serials.

14839. Water Purification in America. Ill. (E N–Began Aug. 3—9 parts to date—15 cts. each).

19132. The Metropolitan Sewerage System of Massachussetts. Ill. (E N–Began Jan. 25 —3 parts to date—15 cts. each).

19813. American Plumbing. Ill. (D E–Began Feb.—3 parts to date—30 cts. each).

21132. Sanitary Law. A. Wynter Blyth (I C B–Began March 30—2 parts to date—30 cts. each).

STEAM ENGINEERING.

21185. Combining Indicator Diagrams from Compound Engines. Ill. Frank H. Ball (A M–April 12.) 1100 w.

21220. Origin and Development of Steam Navigation. George H. Preble (From United Service Magazine) (Eng–April 14.) 2500 w.

21233. Buying Steam Boilers.—Why the Best Should be Obtained (B J C–April 14.) 900 w.

21246. Economy in Steam Generation. J. C. McMynn (E E–April.) 650 w.

21250. The Need and the Advantage of Feed-Water Heaters. W. H. Wakeman (T–April 15.) 2000 w.

21251. Improvement in Steam Engineering as Related to Southern Progress in Manufacturing. Leicester Allen (T–April 15.) 1200 w.

*21267. Heat Economizers. Sydney H. Hollands (P Eng–April 6.) 3000 w.

*21327. Oil and Petroleum Engines (Abstract) H. M. Waynforth (I C T–April 6.) 4000 w.

21335. The Edson Pressure Recording Gauge Receives the John Scott Legacy Medal and Premium. Ill. (E R N Y–April 18.) 900 w.

21341. The Economical Use of Soft Coal. Henry Bland (S V–April 15.) 1100 w.

21406. Some Boiler Notes.—Clogged Water Column and a Bagged Sheet (B J C–April 21.) 900 w.

21407. Ratio of Heating Surface to Grate Surface in Boilers (B J C–April 21.) 900 w.

21585. The De Laval Turbine.—A Wheel that Spins at the Rate of 30000 Revolutions a Minute (B J C–April 28.) 900 w.

*21652. Liquid and Solid Fuel Supplies. Editorial (Eng L–April 20.) 1600 w.

*21653. A Thermodynamic Puzzle. Editorial (Eng L–April 20.) 1800 w.

21657. Steam Boiler Trials.—The Youths' Companion Building, Boston (M G–April 28.) 1000 w.

21676. Effect of Steam Bubbles on Circulation. Ill. (P S–May.) 1800 w.

21677. Economy in Compound Engine Plants. Samuel M. Green (P S–May.) 1200 w.

21678. Smoke Prevention (P S–May.) 800 w.

21704. The New Porter Steam Engine. Ill. (Ir Age–May 3.) 4500 w.

*21753. A New System of Smoke Absorption or Suppression. Ill. (Inv–April 14.) 1500 w.

21754. Cylinder Condensation.—The Effect of Rough Surfaces (B J C–May 5.) 1000 w.

21791. Steam Boiler Tests at Youths' Companion Building by Alfred A. Hunting.—Second Trial (M G–May 5.) 450 w.

*21805. Steam on Common Roads (E–April 27.) 3000 w.

21854. The Evolution of the Steam Boiler. J. H. Killey (C E N–May.) 2200 w.

21862. The Compound Engines at the Centennial. Ill. Fred H. Colvin (A M–May 10.) 1400 w.

21863. New and Simple Formulas for Saturated Steam. G. B. Maynadier (A M–May 10.) 650 w.

21891. Results of Boiler Tests Made by the Robert W. Hunt and Company. Table (Ir Age–May 10.) 800 w.

Serials.

13033. Practical Hints to Boiler Makers and Templaters. Ill. (M W–Began May 12, 1893 —9 parts to date—30 cts. each).

16756. Theory of Steam Engine Governors. Ill. J. Begtrup (A M–Began Oct. 19—5 parts to date—15 cts. each).

18169. Power Plant in the Realty Building. Ill. (E R–Began Dec. 16—2 parts to date—15 cts. each).

18986. Boiler Calculations. James F. Hobart (S M–Began Jan. 15—5 parts to date—15 cts. each).

19709. The Indicator and Its Diagrams. Charles Day (P Eng–Began Feb. 2—8 parts to date—30 cts. each).

20182. The Elements of Boiler-Making. Ill. C. E. Fourness (L E–Began March—3 parts to date—30 cts. each).

20568. The Stationary Engineers as They Were and as They Are. Stephen Roper (S V–Began March 15—Ended April 15—2 parts—15 cts. each).

21064. The Testing of Engines and Boilers. Alexander B. W. Kennedy (El–Began March 30—Ended April 20—2 parts—30 cts. each).

TELEPHONY AND TELEGRAPHY.

21168. Telephone Rates in Europe (E R N Y–April 11.) 1300 w.

21178. The Mercadier and Anizan Microphone Reducer. Ill. (E E N Y–April 11.) 1100 w.

*21258. Sir Henry Mance's Battery Resistance Test in Its Application to Duplex Telegraphy. Ill. (E R L–April 6.) 650 w.

*21259. An Adjustable Microphone. Ill. W. H. Soulby (E R L–April 6.) 800 w.

*21285. Telegraphic Communication by Induction by Means of Coils. Charles A. Stevenson (E–April 6.) 2000 w.

*21302. The Best Resistance for the Receiving Instrument on a Leaky Telegraph Line. Ill. W. E. Ayrton and C. S. Whitehead (E E L–April 6.) 1200 w.

21338. Telephony Without a Wire. Ill. (E R N Y–April 18.) 900 w.

21353. The Postal Telegraph Cable Company's New Building. Ill. (E W–April 21.) 8000 w.

21371. Invention and Development of the Telephone. Ill. Herbert Laws Webb (W E–April 21.) 1200 w.

*21500. Submarine Telegraphy. A. E. Kennelly (S J E–April.) 2000 w.

Serials.

18628. The Electro-Magnet ; or Joseph Henry's Place in the History of the Electro-Magnetic Telegraph. Mary A. Henry (E E N Y–Began Jan. 3—12 parts to date—15 cts. each).

MISCELLANEOUS.

*21158. Business Opportunities in Peru. Ill. H. Guillaume (E Mag–June.) 3000 w.

*21161. The Pine Industry in the South. Ill. George L. Fowler (E Mag–June.) 3000 w.

21355. The Utilization of the Waste Energy of the World (Sc A–April 21.) 1100 w.

21394. On the Origin of Ancient Quartz Rocks. J. F. Blake (Sc–March 16.) 1500 w.

*21421. The True Meaning of Farm-Mortgage Statistics. Edward Atkinson (F–May.) 6000 w.

21447. Determination of the Refractoriness of Fire-Clays. Ill. H. O. Hofman and C. D. Demond (E M J–April 21.) 1500 w.

*21471. The Apprentice Question. John Inglis (Eng L–April 13.) 3300 w.

*21503. Notes on the Materials of Aeronautic Engineering. R. H. Thurston (S J E–April.) 4500 w.

21514. The Topographical Survey of New York (E N–April 12.) 1800 w.

†21526. Helping People to Help Themselves. Nathan Straus (N A R–May.) 5000 w.

†21542. The Relation of Rubber-Gathering to Manufacture. Francis Harvey (I R W–April 15.) 1800 w.

21544. Denver and Vicinity. Ill. Edward B. Light (G R–April.) 1600 w.

21559. Edward Atkinson on Banking (M R–April 27.) 3000 w.

21615. New England Nationalism. Edward E. Hale (B C–April 28.) 5700 w.

†21666. First Principles of the Land Question. Louis F. Post (A–May.) 5000 w.

†21668. The Philosophy of Mutualism. Frank Parsons (A–May.) 13000 w.

21707. Points in Fertilizer Manufacturing. A. D. Ledoux (M R–May 4.) 1800 w.

*21710 The Fusibility of Clays. H. A. Wheeler (P–May.) 1500 w.

*21749. Engineers of To-Day and Yesterday. John Gjers. Ill. (E Rev–April 20.) 1500 w.

†21765. A Reconnoissance of the Abandoned Shore Lines of Green Bay. F. B. Taylor (A G–May.) 4000 w.

†21766. American Species of Autodetus and Some Paramorphic Shells from the Devonian. Ill. John M. Clarke (A G–May) 2500 w.

*21792. Evolution in Decorative Art. Henry Balfour, with Discussion (J S A–April 27.) 10000 w.

*21793. The Face of the Earth. Charles Lapworth (N–April 26.) 3800 w.

*21798. Carnot and Modern Heat.—Criticising Dr. Lodge's paper (Eng L–April 27.) 1500 w.

21873. A Botanic Garden for New York (G & F–May 9.) 900 w.

21886. Isoperimetrical Problems. Lord Kelvin (Sc A S–May 12.) 3000 w.

Serials.

18930. Carnot and Modern Heat. Dr. Oliver Lodge (Eng L–Began Jan. 5—11 parts to date—30 cts. each).

20802. Measurement of High Temperatures. Ill. A. Humboldt Sexton (P Eng–Began March 23—3 parts to date—30 cts. each).

21067. Geological Notes on the Sierra Nevada. H. W. Turner (A G–Began April—Ended May—2 parts—45 cts. each).

21269. Aerial Flight : the Steering of Balloons. Ill. (P Eng–Began April 6—Ended April 13—2 parts—30 cts. each).

21450. Evolution in Decorative Art. Henry Balfour (A L–Began April 13—Ended April 20—2 parts—30 cts. each).

21472. Some American Inventors and Their Achievements (Inv–Began April 14—3 parts to date—30 cts. each).

21518. The Mid-Winter Fair. Ill. (E W–Began April 28—3 parts to date—15 cts. each).

21591. The Preservation of Wood. A. M. Villon (E R–Began April 28—1 part to date—15 cts).

21763. Engineering Practice and Education. Gaetano Lanza (J F I–Began May—1 part to date—45 cts).

21816. The Waste Lands of Australia. Ernest Favenc (A P R—Began March—1 part to date—45 cts).

THE·TECHNICAL·INDEX

A CATALOGUE OF LEADING ARTICLES PUBLISHED CURRENTLY IN THE TECHNICAL JOURNALS OF THE UNITED STATES AND GREAT BRITAIN.

THIS index has been very properly described as "the greatest step that has been taken in recent years towards systematizing work" for the engineer, the architect, the electrician, the railway manager, and the business man. The list of publications regularly indexed will show that it covers a world-wide range of the best technical literature, and all the articles are so conveniently classified under general headings, that within a few minutes, once a month, an active man can learn of everything of any importance that has been published during the month in relation to the subjects in which he is interested. In short, it is to the practical man just what Poole's celebrated index to periodicals has long been to the literary worker, but with this essential improvement—namely: that in addition to indicating *just when and where* leading articles have been published, *we undertake to supply copies of the articles themselves.* The unparalleled convenience and economy of this double service can readily be appreciated.

IN ordering articles from us, care should be taken to give the *number*, not the title alone. The price of a single article is 15 cents; those indicated by an asterisk (*), 30 cents, and by a dagger (†), 45 cents; and where the cost is above this, the price is given immediately after the number. In every case the price is closely regulated by the cost to us of a single copy of the publication from which the article is taken.

To avoid the inconvenience of small remittances and to cheapen the cost of articles to those who order frequently, we sell coupons at the rate of 15 cents each, or 15 for $2, 40 for $5, and 100 for $12.50. Each coupon is receivable in exchange for one 15–cent article; those marked * require two coupons; those marked † require three coupons; and for the articles of higher price, one coupon for each 15 cents: thus, a 75c. article requires five coupons. Samples of these coupons *will be sent free* for examination. They need only a trial to demonstrate their great convenience and economy.

[In the body of the index only the initials of the journals quoted are given, and these can be readily identified by the following list of periodicals. Other abbreviations are: Ill=Illustrated. w=words.]

THE AMERICAN PRESS.

A	Arena. *m.* $5. Boston.
AA	American Architect. *w.* $6. Boston.
An A A	Annals of Am. Academy of Political and Social Science. *b-m.* $6. Philadelphia.
A An	American Analyst. *f.* $1. New York.
A Ar	American Artisan. *w.* $2. Chicago.
A & B	Architecture and Building. *w.* $6. N. Y.
A B D	Architect, Builder and Decorator. *m.* $2. Minneapolis.
A CJ	Am. Chem. Journal. *b-m.* $4. Baltimore.
A E R J	Am. Eng. and Railroad Journal. *m.* $3. N.Y.
A G	Am. Geologist. *m.* $3.50. Minneapolis.
A G L J	Am. Gas Light Journal. *w.* $3. New York.
A H	Annals of Hygiene. *m.* $2. Phila.
A J P	Am. Jour. of Politics. *m.* $3. New York.
A J Phar	Am. Journal of Pharmacy. *m.* $3. Phila.
A J R A	Jour. R'y. Appliances. *m.* $2. New York.
A J S	Am. Jour. of Science. *m.* $6. New Haven.
A M	American Machinist. *w.* $3. New York.
A M & I W	Am. Man. and Iron World. $4. Pittsburg.
Am S	American Shipbuilder. *w.* $2. New York.
A & N J	Army and Navy Journal. *w.* $6. New York.
A & N R	Army and Navy Register. *w.* $3. Wash'ton.
A R	Architectural Record. *q.* $1. New York.
A Rev	Architectural Review. *s-q.* $5. Boston.
A S	Age of Steel. *w.* $3. St. Louis.
A S M E	Am. Soc. of Mec. Eng. *m.* New York.
B B	Brick Builder. *m.* $2.50. Boston.
B C	Boston Commonwealth. *w.* $2.50. Boston.
B D	The Black Diamond. *w.* $3. Chicago.
B G S	Bul. Am. Geog. Soc. *q.* $5. New York.
B I S	Bul. Am. Iron and St. Asso. *w.* $4. Phila.
B J C	Boston Jour. of Commerce. *w.* $3. Boston.
B & W	Builder and Woodworker. *m.* $1. N. Y.
C	Compass. *m.* $1. New York.
C A	Calif. Architect. *m.* $3. San Francisco.
Can A	Canadian Architect. *m.* $2. Toronto.
C & B	Carpentry and Building. *m.* $1. New York.
C E	Colliery Engineer. *m.* $2. Scranton, Pa.
C E N	Canadian Elec. News. *m.* $1. Toronto.
C Eng	Canadian Engineer. *m.* $1. Montreal.
Ch	Chautauquan. *m.* $2. Meadville, Pa.
C M	Century Magazine. *m.* $4. New York
C M R	Canadian Mining Rec. *m.* $1.50. Ottawa.
Cos	Cosmopolitan. *m.* $1.50. New York.
D E	Domestic Engineering. *m.* $2. Chicago.
E A	Electrical Age. *w.* $3. New York.
E E	Electrical Engineering. *m.* $1. Chicago.
E E N Y	Electrical Engineer. *w.* $3. New York.
E I	Electrical Industries. *m.* $1. Chicago.
Elek	Elektron. *m.* $3 Boston
E M	Engineering Mechanics. *m.* $2. Phila.
E Mag	Engineering Magazine. *m.* $3. New York.
E M J	Eng. and Mining Journal. *w.* $5. N.Y.
E N	Engineering News. *w.* $5. New York.
Eng	Engineer. *s-m.* $2. New York.
E N Y	Electricity. *w.* $2.50. New York.
E R	Engineering Record. *w.* $5. New York.
E R N Y	Electrical Review. *w.* $3. New York.
E S W P	Proc. Eng. So. of W. Pa. *m.* $7. Pittsburg.
E W	Electrical World. *w.* $3. New York.
F	Forum. *m.* $3. New York.

F D......The Foundry. *m.* $1. Detroit.
F W .....Fire and Water. *w.* $3. New York.
G & F....Garden and Forest. *w.* $4. New York.
G R......Good Roads. *m.* $1. New York.
I A......Inland Architect. *m.* $5. Chicago.
I Age....Inventive Age. *s-m.* $1. Washington.
Ir Age..Iron Age. *w.* $4.50. New York.
I I G.....Iron Ind. Gazette. *m.* $1.50. Buffalo.
I R W...India Rubber World. *m.* $3 New York.
I S F.....Industry. *m.* $2. San Francisco.
I T R....Iron Trade Review. *w.* $3. Cleveland.
J A C S..Jour. Am. Chem. So. *m.* $5. Easton.
J A E S. Jour. Assoc. Eng. Soc. *m.* $3. Chicago.
J A N E..Jour. Am. Soc. Naval Engineers. *qr.* $5. Washington.
J F I.....Jour. Franklin Institute. *m* $5. Phila.
J M S I..Jour. Milit. Service In. *b-m.* $4. NewYork.
J N E W.Jour.N.E.Waterw. As. *q.* $2. New London.
J P E.....Jour. Polit. Economy. *q.* $3. Chicago.
J U S A..Jour. U. S. Artillery. *q.* $2.50. Ft. Monroe.
L E......Locomotive Engineering. *m.* $2. N. Y.
L. H. P..Light, Heat and Power. *m.* $3. Phila.
L Mag...Lippincott's Magazine. *m.* $3. Phila.
M & B...Manufacturer and Builder. *m.* $1.50. N. Y.
Met W...Metal Worker. *w.* $2. N. Y.
M G......Manufacturer's Gazette. *w.* $3. Boston.
Mill......Milling. *m.* $2. Chicago.
Min. R...The Mining Review. *w.* $2. Denver.
M I T....Mining Industry. *w.* $3. Denver.
Ml N....The Monumental News. *m.* $1. Chicago.
M R......Manufacturer's Record. *w.* $4. Baltimore.
M R C...Marine Review. *w.* $2. Cleveland, O.
M Rec....The Marine Record. *w.* $2. Cleveland.
M S P....Min. and Sci. Press. *w.* $3. San Francisco.
N A R...North American Review. *m.* $5. N. Y.
N B......National Builder. *m.* $3. Chicago.
N C B...National Car Builder. *m.* $2. New York.
N E M..New Eng. Magazine. *m.* $3. Boston,
N P R...Nat. Popular Review. *m.* $2.50. Chicago.
N W.....Nowest. Architect. *m.* $3. Minneapolis.
O P D R..Oil, Paint and Drug Reporter. *w.* $6. N.Y.
P.........Paving. *m.* $2. Indianapolis.
P A .....Progressive Age. *s-m.* $3. New York.
P E C P.Procd. Engineer's Club. *q.* $2. Phila.
Pr.......Power. *m.* $1. N. Y.
P S M....Popular Science Monthly. *m.* $5. N. Y.
R A.....Railway Age. *w.* $4. Chicago.
R C J....Railroad Car Journal. *m.* $1. New York.
R E M....Railway Engineering and Mechanics. *m.* $1. Chicago
R G .....Railroad Gazette. *w.* $4.20. N. Y.
R M.....Roller Mill. *m.* $2. Buffalo, N. Y.
R of R...Review of Reviews. *m.* $2.50. New York.
R R......Railway Review. *w.* $2. Chicago.
R & T...Roofer and Tinner. *m.* $1. N. Y.
S... .....Stone. *m.* $2. Chicago.
S A......Southern Architect. *m.* $2. Atlanta.
San......Sanitarian. *m.* $4. Brooklyn.
Sc........Science. *w.* $3.50. New York.
Sc A.....Scientific American. *w.* $3. New York.
Sc A S...Scientific Am. Supplement. *w.* $5. N. Y.
Sc M....Scribner's Magazine. *m.* $3. New York.
S E .....Stationary Engineer. *w.* $2. Chicago.
Sc Q.....Scientific Quarterly. *q.* $2. Golden, Cal.
Sea......Seaboard. *w.* $2. New York.
S Ec.....Social Economist. *m.* $2. New York.
S J E....Sibley Jour. of Eng. *m.* $2. Ithaca, N. Y.
S M.....ScientificMachinist.*s-m.*$1.50. Cleveland,O.
So L.....Sou. Lumberman. *s-m.* $2. Nashville.
S M Q....School of Mines Quarterly. $2. N. Y.
S R E N..St. R'y. Elec. News. *m.* $2. Minneapolis.
S P......Sanitary Plumber. *s-m.* $1. New York.
S R G....Street Railway Gazette. *w.* $3. Chicago.
S R J....Street Railway Journal. *m.* $4. New York.
S R R.. .Street Railway Review. *m.* $2. Chicago.
S V......Safety Valve. *m.* $1. New York.
T ....Tradesman. *s-m.* $2. Chattanooga, Tenn.
T A I E E.Trans. Am. Ins. Elec. Eng. *m.* $5. N. Y.
T C E... Trans. Am. Soc. Civil Eng. *m.* $10. N. Y.
Tech ..The Technograph. Champaign. Ill.
T Q......Technology Quarterly. $3. Boston.
Tr A M E.Trans. Am. Ins. of Mining Eng. N. Y.
T W A .Trans. of the Wis. Acad. Madison.
W E......Western Electrician. *w.* $3. Chicago.

THE FOREIGN PRESS.

A L.....The Architect. *w.* 26*s.* London.
A M S.. Aust. Mining Standard. *w.* 30*s.* Sydney.
A P R...Aus. Pastoralists' Rev. *m.* 20*s.* Sydney.
B A.... .The British Architect. *w.* 23*s.* 8*d.* London.
C G.. ..Colliery Guardian. *w.* 27*s.* 6*d.* London.
C R......Contemporary Review. *m.* $4.50. London.
C T J....Chem. Trade Jour. *w.* 12*s.* 6*d.* Manchester.
E.........Engineering. *w.* 36*s.* London.
E E L....Electrical Engineer. *w.* 19*s.* 6*d.* London.
E G......Engineers' Gazette. *m.* 8*s.* London.
E L.......Electricity. *w.* 7*s.* 6*d.* London.
El.........Electrician. *w.* 24*s.* London.
EngL... Engineer. *w.* 36*s.* London.
E P......Electrical Plant. *m.* 6*s.* London.
E Rev....Engineering Review. *m.* 7*s.* London.
E R L.....Electrical Review. *w.* 21*s.* 8*d.* London.
F R......Fortnightly Review. *m.* $4.50. London.
G E M...Gas Engrs' Mag. *m.* 6*s.* 6*d.* Birmingham.
G W......Gas World. *w.* 13*s.* London.
I & I.....Industries and Iron. *w.* £1. London.
I & S.....Iron & Steel Trades' Jour. *w.* 25*s.* Lond.
C B... .Carpenter and Builder. *w.* 8*s.* 8*d.* London.
I C T... ..Iron and Coal Trades. *w.* 30*s.* 4*d.* London.
I E.......Indian Engineering. *w.* 18 Rs. Calcutta.
I Eng....Indian Engineer. *w.* 20 Rs. Calcutta.
Inv......Invention. *w.* 11*s.* London.
I S C.... .The Iron, Steel and Coal Times. *w.* £1 6*s.* London.
J G L....Journal of Gas Lighting. *w.* London.
J S A....Journal of the So. of Arts. *w.* London.
M........Machinery. *m.* 9*s.* London.
M E......Marine Engineer. *m.* 7*s.* 6*d.* London.
Min W..The Mining World. *w.* 21*s.* London.
M W.....Mechanical World. *w.* 8*s.* 8*d.* London.
N....... Nature. *w.* $7. London.
N C......Nineteenth Century. *m.* $4.50. London.
P Eng...Practical Engineer. *w.* 10*s.* London.
Pl D .....Plumber and Decor. *m.* 6*s.* 6*d.* London.
R P L....The Railway Press. *m.* 7*s.* London.
R W.....Railway World. *m.* 5*s.* London.
S L......Steamship. *m* Leith, Scotland.
S R......Sanitary Record. *m.* 10*s.* London.
Tr.......Transport. *w.* £1. 5*s.* London.
W R.....Westminster Review. *m.* $4.50. London.

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22570. On the Measurement of the Power of Polyphased Currents. Ill. Alexander D. Lunt (E W–Began June 9—1 part to date—15 cts).

GAS ENGINEERING.

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*22001. Gas and Electric Light. Editorial (Eng L–May 4.) 1200 w.

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*22213. The "Lancet" Commission Report on Gas-Fires. Charles W. Folkard (J G L–May 15.) 2800 w.

*22214. Discussion of H. Lees' paper—"Gas Undertakings in Relation to the Use of Gas Engines" (J G L–May 15.) 3500 w.

*22270. Gaseous Fuel with Special Reference to the Theory of Its Production. A. Humboldt Sexton (I C T–May 18.) 3000 w.

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*22448. Coal Gas and Its Consumption (E–May 25.) 1600 w.

*22454. Enrichment of Coal Gas. J. Fergusson Bell (G W–May 26.) 4200 w.

22462. Some of the Advantages of Oil Gas Plants for Small Towns. J. W. Stratton, with Discussion (A G L J–June 4.) 2400 w.

22463. The Influence of Temperature on Purification. James Ferrier, with Discussion (A G L J–June 4.) 3500 w.

22464. The Best Method of Introducing Gas Stoves. H. Wilkiemeyer, with Discussion (A G L J–June 4.) 7000 w.

22465. History of the Gas Meter. William McDonald, with Discussion (P A–June 1.) 4600 w.

22466. Street Main Pressure. Irvin Butterworth, with Discussion (P A–June 1.) 4800 w.

*22564. A Case for Low Grade Gas (J G L–May 29.) 1800 w.

Serials.

13534. The Gas Engine (M W–Began June 2, 1893—9 parts to date—30 cts. each).

20417. Gas Stoves and Ventilation. Edward J. Smith (Pl D–Began March—3 parts to date—30 cts. each).

21052. The Development of the Gasholder. A. M'I Clelland (J G L–Began March 27—3 parts to date—30 cts. each).

21760. Our Gas Burners, Gas Pressure Regulators and Governor Burners, Gas Globes and Globe Holders, and Gas Fixtures. William Paul Gerhard (J F I–Began May—2 parts to date—45 cts. each).

21887. Testing Gas Engines. J. A. (M W–Began May 4—Ended May 11—2 parts—30 cts. each).

HYDRAULICS.

21924. Notes on the Great Kanawha Improvement and the Chanoine Wicket Dams. Addison M. Scott (E N–May 10.) 700 w.

21925. A Simple Hydraulic Formula for Water Power Computation. William Cox (E N–May 10.) 300 w.

†22038. Nile Reservoirs and Philæ. Benjamin Baker (N C–May.) 4500 w.

22076. A Water-Power Pumping Plant for Irrigation—Prosser Falls, Washington. Ill. (E N–May 17.) 500 w.

*22144. Municipal and Village Water Supply and Sanitation in the Northwest Provinces and Oudh. Auckland Colvin, with Discussion (J S A–May 11.) 14500 w.

22220. Estimate of the Distance to Which Niagara Water-Power Can Be Economically Transmitted by Electricity. Charles E. Emery (E E N Y–May 23.) 1300 w.

22240. The Niagara Falls Power Plant. Ill. (E N–May 24.) 4000 w.

22302.—75 cts. Filter at the Wannacomet Water Works, Nantucket, Mass. Ill. William T. Codd (J N E W–June.) 1500 w.

22303.—75 cts. The Fairhaven, Mass., Water Works. Ill. Joseph K. Nye, with Discussion (J N E W–June.) 3000 w.

22305.—75 cts. Some Measurements of the Flow of Water in a 36″ and 30″ Compound Pipe. Ill. L. M. Hastings, with Discussion (J N E W–June.) 2000 w.

†22332. Engineering Notes on Irrigation Canals. W. Newbrough (S M Q–April.) 9500 w.

22392. Reclaiming a Swamp (M R–June 1.) 900 w.

22407. The Present and Proposed Source of Water Supply of Saginaw, Mich. W. R. Coats (E N–May 31.) 800 w.

22411. Pumping Water for Irrigation in Arizona (E N–May 31.) 1700 w.

*22449. The Richmond Lock and Weir (E–May 25.) 1400 w.

†22559. Irrigation by Pumping. Ill. Alfred Chatterton (I E–May 5.) 900 w.

22633. Lake McMillan Dam, Pecos River. Ill. (E R–June 9.) 600 w.

Serials.

16028. About Siphons. Ill. Leicester Allen (A M–Began Sept. 21—5 parts to date—15 cts. each).

18676. The Pumping Engine; Its Many Points, Faults and Peculiarities. Ernest W. Naylor (F W–Began Jan. 6—15 parts to date—15 cts. each)

18801. Discharge of Sluices and Weirs under Varying Heads. G. C. Maconchy (I E–Began Dec. 9, 1893—14 parts to date—45 cts each).

20466. Details of Modern Water-Works Construction. Ill. Wolcott C. Foster (S M Q–Began Jan.—2 parts to date—45 cts. each).

21015. Stand-Pipe Accidents and Failures. Ill. William D. Pence (E N–Began April 5—8 parts to date—15 cts. each).

21021. The Missouri River. O. B. Gunn (R G–Began April 6—Ended May 25—3 parts—15 cts. each).

21433. Glasgow Water Works. Ill. (E–Began April 13—4 parts to date—30 cts. each).

21551. Application of Hydraulic Machinery to the Manchester Trade. Ill. Gilbert Lewis (M W–Began April 20–Ended May 18—3 parts—30 cts. each).

22418. Emery's Hydraulic Testing Machines. Ill. (E W–Began May 21—1 part to date—30 cts).

INDUSTRIAL CHEMISTRY.

†22335. Schemes for Qualitative Analysis. J. S. C. Wells and A. R. Cushman (S M Q–April.) 3000 w.

†22540. A Convenient Still for the Laboratory. Charles E. Wait (Tr A M E–June.) 500 w.

†22542. The Refining of Gold Sulphides Produced by the Precipitation of Gold from Chlorine, or Bromine Solution with Sulphurous Acid and Hydrogen Sulphide. Ill. Werner Langguth (Tr A M E–June.) 1700 w.

Serials.

15176. The Chemical and Physical Examination of Portland Cement. Thomas B. Stillman (J A C S–Began April, 1893—3 parts to date—45 cts. each).

19453. Contributions to the Chemistry of India-Rubber. P. Carter Bell (I R W–Began Jan. 15—4 parts to date—45 cts. each).

INDUSTRIAL SOCIOLOGY.

*21908. The Danger Lurking Behind Strikes. William Nelson Black (E Mag–July.) 3000 w.

†22033. Woman and Labor. Karl Pearson (F R–May.) 8000 w.

22116. Enemies to Labor. A. B. Salom (I I G–May.) 1200 w.

*22124. Trades Unionism. Hugh Glen (Eng L–May 11.) 2000 w.

22138. Profit Sharing. C. S. Prizer (A Ar–May 19.) 3700 w.

22158. Strike at the Pullman Car Works, with Editorial (R A–May 18.) 2500 w.

*22178. Distribution of Wealth in the United States. William A. Scott (Ch–June.) 4000 w.

*22180. Coxey's Commonweal Army. Shirley Plumer Austin (Ch–June.) 3000 w.

*22249. Employers and Employed. Editorial (E–May 18.) 1700 w.

*22257. Who Will Pay the Bills of Socialism? E. L. Godkin (F–June.) 5200 w.

*22259. How Baltimore Banished Tramps and Helped the Idle. E. R. L. Gould (F–June.) 3500 w.

†22318. Protection and the Proletariat. J. Sterling Morton (N A R–June.) 2500 w.

†22319. The Menace of "Coxeyism"—I. Significance and Aims of the Movement. O. O. Howard. II. Character and Methods of the Men. Thomas Byrnes. III. The Danger to the Public Health. Alvah H. Doty (N A R–June.) 7200 w.

*22320. Economic Coöperation. Stoughton Cooley (A J P–June.) 5000 w.

*22321. Australia and the American Continent. T. Castelle Hopkins (A J P–June.) 6000 w.

*22322. The Money Question and the Unemployed. George G. Merrick (A J P–June.) 3200 w.

*22323. How to Abolish Poverty. Ellen Battelle Dietrick (A J P–June.) 3000 w.

*22324. What Ails Inter-American Commerce? Kurt von Staufen (A J P–June.) 2500 w.

*22325. An Artificial Panic in Retrospect. William Knapp (A J P–June.) 4300 w.

22380. The Labor Situation. Editorial (R R–May 26.) 1000 w.

†22388. Child Slavery in America.—A Symposium. I. The Child, the Factory and the State. Alzina P. Stevens. II. Child Labor an Obstacle to Industrial Progress. Alice L. Woodbridge. III. Important Data Compiled and Condensed from Original Sources. Thomas E. Will (A–June.) 12000 w.

22455. The Coal Strikes (M G–June 2.) 600 w.

*22457. A Living Wage. Ewing Matheson (I & S–May 26.) 3500 w.

22494. Riot Rising Rampant (B D–June 2.) 950 w.

22563. An Extraordinary Combination—Influences Tending to Unsettle Business (Ir Age–June 7.) 1300 w.

22576. The Coal Strike and Its Lessons (Sc A–June 9.) 900 w.

LANDSCAPE ENGINEERING.

22039. The Charles River at Boston (G & F–May 16.) 2000 w.

22520. Playgrounds and Parks (G & F–June 6.) 1200 w.

MARINE ENGINEERING.

*21900. Saving a Wrecked Vessel. Ill. Gustave Kobbé (E Mag–July.) 3000 w.

*21907. Early Steamboats on the Great Lakes. J. F. Holloway E Mag–July.) 3000 w.

*21990. The Lengthening of the South African Liner "Moor" (E–May 4.) 1100 w.

*22155. Breakdowns at Sea—Review of book by A. Ritchie Leask (Tr–May 11.) 1500 w.

22210. Naphtha Launches for Pleasure or Profit. Ill. (Sea–May 24.) 2700 w.

*22272. The Arctic Expeditions of 1894. Hugh Robert Mill (N–May 17.) 2500 w.

*22292. The Suez Canal Shipping (Tr–May 18.) 800 w.

22349.—$1.25. The Accident to the City of Paris. Ill. Otto H. Mueller (J A N E–May.) 17500 w.

22351.—$1.25. Circulation in the "Thornycroft" Water-Tube Boiler. Ill. J. I. Thornycroft (J A N E–May.) 2600 w.

22352.—$1.25. Water-Tube Boilers. Ill. J. T. Milton (J A N E–May.) 5600 w.

22353.—$1.25. On the Comparative Merits of Cylindrical and Water-Tube Boilers for Ocean Steamships. James Howden, with Discussion (J A N E–May.) 15500 w.

22402. Free Ships or a Discriminating Tariff. W. I. Babcock (Sea–May 31.) 2800 w.

22403. The Ethics and Economics of Transportation. William W. Bates (Sea–May 31.) 1000 w.

*22499. The Opening of the Ship Canal (Tr–May 25.) 3200 w.

*22500. The Destruction of Derelicts (Tr–May 25.) 1000 w.

22578. The Rudolf Muller Boiler Furnace on the Steamship Grimm. Ill. (Sc A–June 9.) 500 w.

*22598. Recent Types of Ferry Steamers. (Abstract.) Andrew Brown (M W–June 1.) 1500 w.

Serials

16636. Marine Engine Design (M W—Began Oct. 6—9 parts to date—30 cts. each).

21879. Water Tube Boilers—Reply to Criticism. W. A. Carlile (Am S–Began May 10—Ended May 31—4 parts—15 cts. each).

21969. The Shark and the Sailor. A. L. V. E. (I E–Began April 14—3 parts to date—45 cts. each).

22599. Forced and Induced Draught as Applied to Marine Boilers. R. C. Dowie (M W–Began June 1—1 part to date—30 cts).

MECHANICAL ENGINEERING.

22021. The Tool Room. B. F. Spalding (A S–May 12.) 2000 w.

22069. Some Old Practice in Engine Building. W. H. Booth (A M–May 17.) 2400 w.

*22115. The Relation of Machinery to Commercial and Industrial Depression (Inv–May 12.) 3300 w.

*22142. Glaziers' Diamonds (I C B–May 11.) 800 w.

22150. Economy of Operation of Elevator Installations. Editorial (E R–May 19.) 900 w.

22174. The Specialization of the Machinist Trade. F. J. Masten (S M–May 15.) 1000 w.

†22197. The Relation of the Drawing Office to the Shop in Manufacturing. A. W. Robinson (A S M E–June.) 3600 w.

†22200. A New Mechanical Fluid. Ill. Charles Wallace Hunt (A S M E–June.) 1500 w.

†22202. A Note on Compressed Air. Frank Richards (A S M E–June.) 4000 w.

22203. Steel for Safes. W. F. Durfee (A M–May 24.) 1000 w.

22205. Comparison of Various Rules for Area of Lever Safety Valves. William Kent (A M–May 24.) 1500 w.

*22277. The Phonograph at Work (I C B–May 18.) 1400 w.

22287. The American Watch. Ill. (M & B–April.) 1200 w.

†22341. Cost of Machine Tools per Pound. W. H. VanDervoort (Tech–1893–94.) 1200 w.

22348—$1.25. On the Inertia Stresses of a Slide Valve. Ill. John H. Macalpine (J A N E–May.) 4500 w.

22367. Throttling vs. Automatic Cut-off—Balancing Pulleys and Fly-Wheels. W. H. Booth (A M–May 31.) 1200 w.

22370. Russian Factory Hands.—From the Evening Post (A M–May 31.) 2100 w.

22458. Cross Belts and Belting Tests. R. James Abernathey (Pr–June.) 1300 w.

22459. Hot Journals. C. R. Tompkins (Pr–June.) 1400 w.

*22470. Design and Repairs (Eng L–May 25.) 1600 w.

*22502. Hemp Ropes v. Leather Belts for Hot Climates (P Eng–May 25.) 1500 w.

22579. Cauderay's Electric Clock. Ill. (Sc A S–June 9.) 1000 w.

22597. Notes on Wire Rope Tramways. A. C. Savage (E N–June 7.) 1000 w.

Serials.

17900. Machine Shop Milling Practice. Horace L. Arnold (A M—Began Dec. 7—9 parts to date—15 cts. each).

18044. Motive Power and Gearing. Ill. E. Tremlett Carter (El–Began Dec. 1—15 parts to date—30 cts. each).

19638. Blowing Engines and Machinery. Ill. Albrecht von Ihering (E M–Began Feb—4 parts to date—30 cts. each).

19802. Mechanical Refrigeration. Ill. R. C. Carpenter (S J E–Began Feb—4 parts to date—30 cts. each).

20900. Mechanical Drawing — Elementary Hints for Shopmen. Ill. (T–Began April 1—4 parts to date—15 cts. each).

21762. Emery and Other Abrasives. T. Dunkin Paret (J F I–Began May—Ended June—2 parts—45 cts. each).

21818. Systems of Piece Work (I S F–Began May—2 parts to date—30 cts. each).

21819. On the Transmission of Power. A. E. Chodzko (I S F–Began May—2 parts to date—30 cts. each).

22206. An Improvement in Cable-driving Machinery. Ill. M. W. Sewall (A M–Began May 24—2 parts to date—15 cts. each.)

22414. Oil and Petroleum Engines. H. M. Waynforth (M W–Began May 25—2 parts to date—30 cts. each).

22525. The Manufacture of Fire and Thief Proof Safes (I & I–Began May 18—1 part to date—30 cts.).

METALLURGY.

21919. The Cornish Tin Streams (M S P–May 5.) 1400 w.

21959. The Brown Horse-Shoe Furnace. Ill. (E M J–May 12.) 1000 w.

*21972. The Walrand-Legénisel Process as Applied to Steel Castings. George J. Snelus, with Discussion (I C T–May 4.) 5500 w.

*21973. Methods of Preparing Polished Surfaces of Iron and Steel for Microscopic Examination. J. E. Stead (I C T–May 4) 5800 w.

*21974. Scandinavia as a Source of Iron Ore Supply. Jeremiah Head, with Discussion (I C T–May 4.) 10000 w.

*21975. The Analysis of Steel. (Abstract.) H. K. Bamber (I C T–May 4.) 1300 w.

21979. The Erratic Square Test Bar. Thomas D. West, with Discussion (I T R–May 10.) 5500 w.

*21980. The Forest of Dean as a Producing Field for Bessemer Ores. Walter J. May (I S C–May 4.) 1100 w.

*21988. Nickel: Its History, Uses, and Distribution. A. G. Charleton, with Discussion (J S A–May 4.) 13000 w.

†22035. The Appreciation of Gold. Robert Barclay (F R–May.) 1300 w.

22040. A Method of Ascertaining the Value of Iron Ore, Limestone and Coke in Blast Furnace Use. R. E. Chambers (Ir Age–May 17.) 1500 w.

22041. Coking in Retort Ovens and the Recovery of By-Products (Ir Age–May 17.) 2500 w.

*22054. The Dry Concentration of Ores.—Stuckey and May's Patent (A M S–April 14.) 1800 w.

22081. The Economic Advantages of Smelting Pyrites by Utilizing their Fuel Qualities (M S P–May 12.) 1800 w.

22096. Cleaning Castings. A. C. Mott (Met W–May 19.) 2000 w.

*22108. Capacity and Form of Blast Furnaces. (Abstract) William Hawdon, with Discussion (E–May 11.) 4000 w.

*22109. Remarks on papers of J. O. Arnold, R. A. Hadfield, and M. F. Osmond on "Influence of Elements on Iron" (E–May 11.) 4000 w.

22119. Foundry Management. Dwight Truesdale (F D–May 10) 3300 w.

22120. The Danger of Using the Hand Hammer in the Testing of Cast Iron Pipes. S. Groves (F D–May 10.) 400 w.

*22165. The Results of Heat Treatment on Manganese Steel and Their Bearing upon Carbon Steel. R. A. Hadfield (I & S–May 12.) 8000 w.

*22166. The Physical Influence of Elements on Iron. (Abstract.) J. O. Arnold (I C T–May 11.) 9800 w.

22177. The MacArthur-Forrest Process (M I T–May 17.) 3500 w.

†22184. Rustless Coatings for Iron and Steel.—Tinning and Enameling Metals, Lacquering, and Other Preservative Methods. Ill. M. P. Wood (A S M E–June.) 13500 w.

22223. The Influence of Varying Temperature on Metals. Ill. M. Rudeloff (Ir Age–May 24.) 1500 w.

22224. The Morgan Continuous Billet Mill. Ill. (Ir Age–May 24.) 1700 w.

22244. Loss of Gold in Milling Ore. G. F. Deetken (M S P–May 19.) 900 w.

*22269. Relations between the Chemical Constitution and Ultimate Strength of Steel. (Abstract.) William R. Webster (I C T–May 18.) 1200 w.

*22278. Carriage Iron-Work. R. Burgess (I C B–May 18.) 1800 w.

*22291. Practical Hints on the Working of Wrought-Iron. Henry Longden (A L–May 18.) 4200 w.

*22312. The Sampling of Ores and Tailings (Min W–May 19.) 1650 w.

22375. Progress in Iron-Making in the South. John Birkinbine (Ir Age–May 31.) 4800 w.

*22404. Structural Changes in Wrought Iron. Howard Stillman (N C B–June.) 1800 w.

*22453. English and American Iron Consumption (I C T–May 25.) 900 w.

*22497. The Art of the Blacksmith (I C B–May 25.) 1000 w.

*22522. Estimation of Nickel in Nickel Steel (I & I–May 18.) 1500 w.

†22532. Benjamin Huntsman, of Sheffield, the Inventor of Crucible Steel. Ill. R. A. Hadfield (Tr A M E–June.) 3500 w.

†22533. Gold-Milling at the North Star Mine, Grass Valley, Nevada County, Cal. Ill. Emile Rector Abradie (Tr A M E–June.) 2000 w.

†22535. The Heat-Treatment of Steel. Henry M. Howe (Tr A M E–June.) 20700 w.

†22538. The Allotropism of Gold. Henry Louis (Tr A M E–June.) 1600 w.

22561. The Amalgamated Scale for Iron and Steel Workers (Ir Age–June 7.) 1200 w.

22566. Foundry Use of Physical and Chemical Tests. W. J. Keep (A M–June 7.) 1300 w.

22614. The Cyanide Process. Walter H. Virgoe (E M J–June 9.) 2200 w.

Serials.

19145. Cupola Management. Edward Kirk. (Met W–Began Jan. 27—Ended May 19—12 parts—15 cts. each).

20737. British Ore Producing Districts to Compete with Spanish Minerals. Walter J. May (Inv–Began March 10—3 parts to date—30 cts. each).

21201. Lacquer and Bronze Work. William Norman Brown (Pl D–Began April—2 parts to date—30 cts each).

21330. Steel and Its Manufacture. Henry Webb (I S C–Began April 6—2 parts to date—30 cts. each).

21558. Method of Capillary Electrolytic Sluice in the Extraction of Gold. J. H. Jory (M S P–Began April 21—2 parts to date—15 cts. each).

21715. Practical Blacksmithing. James F. Hobart (T–Began May 1—2 parts to date—15 cts. each).

21814. Plate Moulding. Ill. J. Horner (P Eng–Began April 27—2 parts to date—30 cts. each).

22104. Variations in the Milling of Gold Ores—Grass Valley, California. Ill. T. A. Rickard (E M J–Began May 19—3 parts to date—15 cts. each).

MILITARY ENGINEERING.

21942. The Use of Water-Tube Boilers in the Navy. Walter M. MacFarland (Eng–May 12.) 3500 w.

21953. Effect of Small Bore Bullets.—The Wounds of the Mannlicher Magazine Rifle. A. M. Fernandez de Ybarra (A & N J–May 12.) 2800 w.

*21994. Whalebacks Unfitted for War Vessels (M R C–May 10.) 800 w.

22014.—$1. Coast Artillery Fire Instruction (J U S A–April.) 59000 w.

22015.—$1. Coast Artillery Practice. J. B. Richardson (J U S A–April.) 9500 w.

22016.—$1. The Attack of a Coast Fortress. I. F. B. Eimslie. II. R. F. Johnson (J U S A–April.) 23500 w.

22065. The Newest Schichan Torpedo Boats—Built for the Brazilian Government. Ill. (Sc A S–May 19.) 500 w.

*22114. The Latest Concerning Dowe's Bullet-proof Coat (Inv–May 12.) 700 w.

*22123. Captain Jaques on American Armor. Editorial (Eng L–May 11.) 1300 w.

22225. The 150-Ton Portable Gun Scales of the Watervliet Arsenal. Ill. (Sc A–May 26.) 900 w.

*22229. Maximilian and Mexico. Ill. John Heard, Jr. (Sc M–June.) 14000 w.

*22230. The Future of the Wounded in War. Archibald Forbes (Sc M–June.) 7200 w.

*22247. The Crampton-Smith Position Finder. Ill. (E-May 18.) 1500 w.

*22251. The French Ironclad "Jaureguiberry." Ill. (E-May 18.) 1600 w.

22261. Test of the "Indiana's" Side Armor. Ill. (E M J-May 26.) 500 w.

22267. The Naval Armor Plate Scandal (Eng–May 26.) 2000 w.

*22299. The Explosion at Waltham Abbey. Editorial (Eng L–May 18.) 1600 w.

22346.—$1.25. Contract Trial of the "Olympia." Ill. R. E. Carney (J A N E–May.) 4800 w.

22347.—$1.25. The Propulsive Power of Screw-Ships. James N. Warrington (J A N E–May.) 3000 w.

22372. Notes on the History of the Breech-Loading Gun. Ill. (Sc A–June 2.) 1800 w.

22373. The Air Ship Division of the German Army. Ill. (Sc A S–June 2.) 700 w.

22381. The Home of Joan of Arc. Ill. W. D. McCrackan (Cos–June.) 1800 w.

†22385. Military Drill in the Schools. Benjamin F. Trueblood (C M–June.) 1000 w.

22390. Harveyized Armor (A & N J–June 2.) 1000 w.

*22472. The Failure of Thick Harveyed Nickel Plates. Editorial (Eng L–May 25.) 1000 w.

22519. A Great Mare's Nest Exposed—The Carnegie Plates. (From the Philadelphia Record) (B I S–June 6.) 700 w.

†22549. Armor Protection for Heavy Guns in Battleships. Ill. William C. Foley (J F I–June.) 2700 w.

22562. Auxiliary Coast Defense (Ir Age–June 7.) 450 w.

Serials.

21989. Krupp Ordnance. Ill. (E–Began May 4—3 parts to date—30 cts. each).

21991. The New Spanish Belted Cruisers. Ill. (E–Began May 4—2 parts to date—30 cts. each).

22523. The Qualities and Performances of Recent First-Class Battleships. W. H. White (I & I–Began May 18—2 parts to date—30 cts. each).

MINING.

*21899. Quarrying Methods of the Ancients. Ill. W. F. Durfee (E Mag–July.) 3000 w.

21934. Coal Fields of Roaring Creek.—Along the West Virginia Central and Pittsburg. Thomas Bruce (M R–May 11.) 1500 w.

21950. An Ancient Indian Quarry. O. T. Mason (I Age–May.) 600 w.

21957. Variations in Bilbao Iron Ore. (Extracts.) Cyriaque Helson (E M J–May 12.) 400 w.

21958. Mining Industry of British Columbia, 1893. S. S. Fowler (E M J–May 12.) 1400 w.

*21995. Working Mines Adjacent to and Under Canals (C G–May 4.) 4500 w.

*21996. Working by Inclined Tranches at the Blanzy Colliery. Ill. Léon Mathet (C G–May 4.) 800 w.

*21998. Some Belgian Combustible Rocks Assimilated or Assimilable to Cannel Coal. Adolphe Firket (C G–May 4.) 900 w.

†22034. The Mines (Eight Hours) Bill. D. A. Thomas (F R–May.) 3000 w.

†22036. The Profits of Coal Pits. G. P. Bidder (N C–May.) 2600 w.

*22047. Gold-Mining an Industry. Robert D. Dixon (A M S–March 24.) 1500 w.

*22049. The Mineral Wealth of Victoria. James Stirling (A M S–March 31.) 3000 w.

*22051. The Central Australian Mineral Fields (A M S–April 7.) 1800 w.

*22053. The Etheridge Goldfield (A M S–April 14.) 2400 w.

22063. The Cryolite of Greenland. Francis H. Knauff (Sc A–May 19.) 950 w.

22075. Coal Fields Around Astor.—In the Circle of the Great Pittsburg Seam. Thomas Bruce (M R–May 18.) 1200 w

22080. Lively Times at Angel's Camp. Eugene B. Cushing (M S P–May 12.) 2000 w.

22125. California Gold Boom (Min R–May 10.) 1200 w.

*22126. Working Mines Adjacent to and under Railways (C G–May 11.) 4200 w.

*22128. Deep Boring on the Canadian System, near Freidstadt, Austria. R. Nelson Boyd, with Discussion (C G–May 11.) 6500 w.

22152. A Compressed-Air Pumping Plant. Ill. (E R–May 19.) 1800 w.

22176. The Geological Age of Gold Deposits. Arthur Lakes (M I T–May 17.) 1800 w.

22243. More about Southern Gold Ores. J. J. Newman (M R–May 25.) 1800 w.

*22254. The Mechanical Ventilation of Collieries.—Discussion at Meeting of Manchester Geological Society (C G–May 18.) 2300 w.

*22255. The Pembrokeshire Coalfield. Ill. John George Summons (C G–May 18.) 1200 w.

22260. The Mineral Production of the United States in 1892 and 1893. (E M J–May 26.) 1000 w.

*22313. Coal Mining in New Zealand (Min W–May 19.) 1000 w.

22316. Points on Coal Exportation (B D–May 26.) 900 w.

22317. The Displacement of Miners' Labor (B D–May 26.) 1000 w.

†22333. A Peruvian Salt Mine. Robert Peele, Jr. (S M Q–April.) 1300 w.

22393. Story of a Texas Mine.—Supposed to Have Been Worked by the Spaniards Many Years Ago (M R–June 1.) 600 w.

22431. The Petroleum Fields of India. R. D. Oldham (O P D R–June 4.) 7500 w.

22435. The Phosphate Situation (C M R–Feb.) 1500 w.

22436. Screening and Cleaning Coal. Henry T. Wales (C M R–Feb.) 4500 w.

22437. Some Remarks on the Gold Production of Nova Scotia and How It May Be Increased. B. C. Wilson, with Discussion (C M R–March.) 2300 w.

22438. Coal Mining in Cape Breton. W. Blakemore (C M R–March.) 1500 w.

22439. Mechanical Appliances for the Shipment of Coal. S. W. Allen (C M R–March.) 7000 w.

22441. A Comparison of Some Systems of Machine Screening, with a Description of the Screens lately Put Down at the Foxes Bridge Colliery, Forest of Dean. G. E. J. McMurtrie (C M R–April.) 3500 w.

22442. Notes on Coal Getting by Machinery. T. H. Wordsworth (C M R–April.) 2200 w.

22443. Notes on Blasting in Coal Mines. H. Bigg-Wither (C M R–April.) 2800 w.

22444. Mica Deposts of the Ottawa District. Tr. R. W. Ells (C M R–April.) 2000 w.

*22452. The Miners' International Conference (I C T–May 25.) 1000 w.

22468. Coosa Coal Field, Alabama. William Brewer (T–June 1.) 1300 w.

†22480. Notes on the Gold Ores of California. H. W. Turner (A J S–June.) 2600 w.

22493. Coal Trade Prospects (B D–June 2.) 900 w.

†22534. The Silver Mines of Lake Valley, New Mexico. Ill. Ellis Clark (Tr R A M E–June.) 7600 w.

†22536. Iron Ores of East Texas. W. Kennedy (Tr A M E–June.) 9000 w.

†22541. Correlations in the Coal Rocks West of Pocahontas, Flat Top, Virginia. C. R. Boyd (Tr A M E–June.) 1200 w.

†22543. The Zinc-Ore Deposits of Southwestern New Mexico. Ill. William P. Blake (Tr A M E–June.) 2800 w.

†22544. Coal-Sections Developed by Recent Operations in Wise County, Virginia. Ill. Franklin Bache (Tr A M E–June.) 1000 w.

22584. Salmon River Mines (M S P–June 2.) 1000 w.

22585. Theories about Formation of Gold Nuggets. George Attwood (M S P–June.) 500 w.

22613. The Moral of the Coal Strike. R. W. Raymond (E M J–June 9.) 1500 w.

22615. The Coalfields of Mexico (E M J–Jan. 9.) 800 w.

*22618. The Ventilation of Mines.—Explanation of the Apparent Superiority of Recent Fans over the Guibal. Ill. Gustave Hanarte (C E–June.) 3000 w.

*22619. The Accident at South Wilkes-Barre.—Presence of Mind and Prompt Action Avert a Terrible Disaster (C E–June.) 1500 w.

*22621. Why Does Coal Coke ? (C E–June.) 2500 w.

Serials.

19079. Talks on Quarrying. Edward H. Williams, Jr. (S–Began Jan.—4 parts to date—30 cts. each).

19682. The Sinking and Equipment of Shafts. Ill. (E–Began Feb. 2—6 parts to date—30 cts. each).

19919. North Queensland Gold Fields (A M S–Began Jan. 6—8 parts to date—30 cts. each).

20407. Mine Surveying.—Methods Employed in the Coal Fields of Pennsylvania. Ill. Otto C. Burkhart (C E–Began March—4 parts to date—30 cts. each).

20413. Mining Methods. Ill. (C E–Began March—4 parts to date—30 cts. each).

20414. Geology of Coal. Ill. (C E–Began March.—4 parts to date—30 cts. each).

20415. Mining Machinery. Ill. (C E–Began March—4 parts to date—30 cts. each).

20416. Chemistry of Mining. Ill, (C E–Began March—4 parts to date—30 cts. each).

21313. The Lancashire Colliery. M. E. (C G–Began April 6—5 parts to date—30 cts. each).

21956. The Goldfields of Western Australia. Albert F. Calvert (E M J–Began May 12—2 parts to date—15 cts. each).

22045. The Wyalong Goldfield (A M S–Began March 24—4 parts to date—30 cts. each).

22055. Commercial Mining. F. Danvers Power (A M S–Began April 14—1 part to date—30 cts).

22127. The Rhenish-Westphalian Coalfield. M. E. Tomson (C G–Began May 11—3 parts to date—30 cts. each).

22440. The Pictou Coal Field (C M R–Began March—1 part to date—15 cts).

22586. The Mineral Hydrocarbons.—Their History, Geography. Geology, Physical and Chemical Properties and Uses. Henry G. Hanks (M S P–Began June 2—1 part to date—15 cts).

22616. Metal Mining and Colliery Work Compared and Contrasted. Albert Williams, Jr. (C E–Began June—1 part to date—30 cts).

22617. A Typical Gold Mine.—Description of the Standley Consolidated Mine, Colorado. Ill. Arthur Lakes (C E–Began June—1 part to date—30 cts).

RAILROADING.

*21901. Development of the Electric Locomotive. Ill. B. J. Arnold (E Mag–July.) 3000 w.

*21902. The Political and Economic Importance of the Great Siberian Railway. Hermann Schonfeld (E Mag–July.) 3000 w.

21926. Amendments to the Interchange Rules (E N–May 10.) 1200 w.

21945. The Bellefontaine Shops of C. C. C. & St. L. Railway. Ill. (R G–May 11.) 900 w.

21946. Modifications of Van Borries' System of Compounding. Ill. (R G–May 11.) 450 w.

21947. English Railroad Companies as Street Carriers. C. H. G. (R G–May 11.) 1900 w.

*21999. Railway Bridge over the Lau-Ho, China. Ill. (Eng L–May 4.) 1800 w.

22017. Discussion of G. P. Conn's paper—"Transportation of Persons having Infectious or Contagious Diseases" (R A–May 11.) 2800 w.

22077. The Rise of the Railroad Club. Editorial (E M–May 17.) 1600 w.

22082. A French Express Compound. Ill. (R G–May 18.) 1500 w.

22083. Air-Brakes and Train Efficiency (R G–May 18.) 1300 w.

22086. The Interstate Commerce Law. Editorial (R G–May 18.) 1500 w.

22087. An Electric Road on a New Plan—Stauzhern (E W–May 19.) 700 w.

*22110. The Webb System of Compounding Locomotives (E–May 11.) 2500 w.

22117. Important Railroad Decision—The Right of Quitting Business (I I G–May.) 800 w.

*22168. Compound Locomotives in Switzerland (A J R A–May.) 700 w.

*22181. The New Northwest Passage to the Orient. J. Macdonald Oxley (L Mag–June.) 2000 w.

*22228. A New System of Block Signals. Arthur A. Skeels (J A E S–March.) 1800 w.

22232. Stock and Debt Watering. (Extract.) George G. Crocker (R G–May 25.) 2000 w.

22233. The New Union Station at Boston. Ill. (R G–May 25.) 2100 w.

22235. Pooling and Anti-Pooling Law. Editorial (R G–May 25.) 1700 w.

22236. High Speed and Quick Action Brakes. Editorial (R G–May 25) 1300 w.

*22293. The North British Railway Company's Locomotives, Past and Present. Ill. A. E. Lockyer (R W–May.) 4000 w.

*22294. The Heberlein Automatic Friction Brake. Ill. (R W–May.) 2000 w.

*22296. The French Railway System (R W–May.) 2000 w.

22308. Shippers' Cars in Railway Equipment (R A–May 25.) 1500 w.

22309. From What Class of Employés Should Locomotive Firemen Be Selected ? W. G. Wattson (R A–May 25.) 2000 w.

†22337. Turntable Frogs. Ill. Milo S. Ketchum (Tech–1893-94.) 900 w.

†22338. The Readjustment of Long Railroad Tangents. William D. Pence (Tech–1893-94.) 2300 w.

†22339. Methods of Handling Freight. A. M. Munn (Tech–1893-94.) 1200 w.

22355. Maximum and Minimum Limits of Reasonableness in Rates. Editorial (R R–May 19.) 900 w.

22356. The Legalization of Traffic Compacts. Commissioner Knapp, and Editorial (R R–May 19.) 4500 w.

22378. Standard Specifications for Structural Steel for Modern Railroad Bridges (R R–May 26.) 1500 w.

22379. Why Not Abolish Car Steps ? Editorial (R R–May 26.) 1200 w.

22395. Storage Battery Lighting on the Chesapeake and Ohio (R G–June 1.) 1000 w.

22396. New Freight Agreement of Western Roads (R G–June 1.) 800 w.

22397. The Gölsdorf System of Compounding Locomotives. Ill. (R G–June 1.) 800 w.

22398. Coaling Wharf of the Pittsburg, Cincinnati and St. Louis Railway. Ill. (R G–June 1.) 600 w.

*22406. Traditions of the Camden and Amboy Railroad.—From Philadelphia Public Ledger (N C B–June.) 1700 w.

*22424. A Trip in Old Mexico. Ill. J. A. H. (L E–June.) 5000 w.

*22425. Reforming the Counterbalance Practice of a Big Road. Ill. (L E–June.) 1500 w.

*22426. Keeping Air Brakes in Working Order (L E–June.) 1500 w.

22507. Another Competing Route to the North Pacific Coast (R A–June 1.) 800 w.

22508. Must the Freight Solicitors Go?—Letter to Editor (R A–June 1.) 1500 w.

22509. Economy in Handling Material (R E M–June.) 2000 w.

22510. Notes on the Operation and Care of Motive Power on German Railways. E. M. Herr (R E M–June.) 1300 w.

22511. Air-Brake Dummy Couplings Instead of Angle Cocks. Ill. J. A. Chubb (R E M–June.) 800 w.

22515. Structural Motion in Modern Railroad Bridges.—Georgia Bridge on the Central Vermont Railroad. Ill. (R R–June 2.) 1800 w.

22516. Railway Distrust of the Interstate Commerce Commission. Editorial (R R–June 2.) 900 w.

22517. American Railway Securities in Europe. Dr. von der Leyden (R R–June 2.) 2200 w.

*22528. Confiscation of the Works and Plant of the Piræus-Larissa Railway.—Statement of Messrs. Eckersley, Godfrey and Liddelow, Contractors (I & I–May 25.) 2000 w.

22577. The Coal Hoisting and Distributing Plant of the Manhattan Elevated Railroad, of New York City. Ill. (Sc A–June 9.) 1300 w.

22587. Mount Lowe Railway. Ill. (M S P–June 2.) 600 w.

22592. Railway Wrecking Trains. Ill. (E N–June 7.) 2200 w.

22595. The Tramp Problem and Train Stealing (E N–June 7.) 900 w.

22602. Interior Decoration of Passenger Cars. Ill. (R G–June 8.) 3600 w.

22603. Supreme Court Decision on the Texas Railroad Law (R G–June 8.) 4000 w.

22604. The Minnesota Anti-Scalper Law (R G–June 8.) 1600 w.

22606. Electric Lighting from the Axle (R G–June 8.) 400 w.

22608. Friction of Connections and Brake Shoe Pressure (R G–June 8.) 1500 w.

22637. Improved Car Service by Reason of Improvements in Car Construction. E. W. Grieves (R C J–June.) 1700 w.

22638. Steel Car Frames. G. R. Joughins (R C J–June.) 1400 w.

22640. The Cleaning of Passenger Cars. A M. Waitt (R C J–June.) 3000 w.

22641. Wear and Tear and Failure Under Fair Usage. George S. Hodgins (R C J–June.) 2500 w.

22642. Hygienic Condition of Passenger Cars. Granville P. Conn (R C J–June.) 2000 w.

22644. Proposed Improvement in Passenger Car Construction.—With Special Reference to the Abolition of Platforms and Vestibules. Ill. Ernest Merrick (R C J–June.) 1500 w.

Serials.

9689. Railroad Car Design. Ill. Arthur Richards (R C J–Began Jan.—4 parts to date—15 cts. each).

18435. Painting a Railway Passenger Car. A. Ashmun Kelly (R E M–Began Jan.—5 parts to date—15 cts. each).

21679. The Reciprocating Parts of a Locomotive. Ill. F. J. Cole (A E R J–Began May—2 parts to date—30 cts. each).

21689. Locomotive Boiler Tests. Ill. James F. Hobart (N C B–Began May—2 parts to date—30 cts. each).

22354. Bills of Lading.—Reply to Viator's Second Article (R R–Began May 19—Ended May 26—2 parts—15 cts each).

22399. Present Practice in Specified Loadings for Railroad Bridges. Ward Baldwin (R G–Began June 1—2 parts to date—15 cts. each).

22639. A Master Car Builder's Reminiscences.—A Review of Some Improvements of the Last Half Century. John Kirby (R C J–Began June—1 part to date—15 cts).

STREET RAILWAYS.

21911. A Plea for Inanimate Power and Steel Roads. Martin Dodge (G R–May.) 2800 w.

21923. T-Rails and Spiral Curves on the Denver Street Railways. Ill. (E N–May 10.) 600 w.

*22008. Electric Welding at St. Louis.—Three and One-Half Miles of Continuous Rails. Ill. (S R R–May 15.) 1600 w.

*22009. High vs. Low Speed Engines.—Reply to C. P. Young. M. A. Green (S R R–May 15.) 2500 w.

*22011. The New Power Houses of the Chicago Street Railroad Company. Ill. (S R R–May 15.) 1800 w.

*22012. The Bristol, England, Tramways. Ill. (S R R–May 15.) 800 w.

*22013. The Sandusky, Milan and Norwalk Electric Railway. Ill. (S R R–May 15.) 1800 w.

*22020. Electric Traction in Railway Tunnels. Frank B. Lea (E E L–May 4.) 1300 w.

22062. The Lawrence Underground Conduit Electric Trolley Railroad. Ill. (Sc A–May 19.) 1300 w.

*22132. The Connelly Motor v. Electricity for Driving Tramcars. Sydney F. Walker (E R L–May 11.) 1100 w.

22153. Frank H. Mason, on Gas Motors for Street Railways in Germany (A G L J–May 21.) 2500 w.

†22182. Tests of a Small Electric Railway Plant. Jesse M. Smith (A S M E–June.) 1500 w.

22234. A City Tax on Street Railway Earnings. J. C. Ransom (R G–May 25.) 1000 w.

22238. The Brott Electric Elevated Bicycle Railway Company. Ill. (E A–May 26.) 1300 w.

22242. Rapid Transit Prospects in New York, Boston and Philadelphia (E N–May 24.) 800 w.

22288. The Barrows Elevated Electric Railway. Ill. (M & B–April.) 1600 w.

*22300. Tests of Reckenzaun Tramway Motors and Gearing. Ill. Philip Dawson (E R L–May 18.) 1500 w.

22330. Barmen Electric Rack Railway. Ill. (S R G–May 26.) 1400 w.

22365. Power Brakes for Electric Motor Cars. Ill. Edward C. Boynton (E W–June 2.) 1200 w.

22400. The Metropolitan Railroads of New York and London. Editorial (R G–June 1.) 1500 w.

22416. The Trolley Appreciated in Brooklyn.—From New York Tribune (W E–June 2.), 1400 w.

†22491. The Cincinnati, Newport and Covington Railway. Ill. (S R J–June.) 6500 w.

*22501. Electric Traction. Editorial (P Eng–May 25.) 2800 w.

22514. Test of the Neversink Mountain Electric Road. Ill. Hermann S. Hering and William S. Aldrich (E W–June 5.) 21800 w.

22629. An Automatic Car Fender.—Invention of Elbridge J. Smith. Ill. (I Age–June.) 1800 w.

Serials.

18225. Experiences of a Superintendent. C. P. Young (S R R–Began Dec.—5 parts to date—30 cts. each).

18549. The Intrinsic Value of Street Railway Investments. Edward E. Higgins (S R J—Began Jan.—6 parts to date—45 cts. each).

18711. Electric Railway Motors: Their Construction and Operation. Nelson W. Perry (S R G–Began Jan. 6—21 parts to date—15 cts. each).

21260. Electric Traction. C. H. Wilkinson (E P–Began April—2 parts to date—30 cts each).

21747. Steam Tramway Locomotives. Ill. (R W–Began April—2 parts to date—30 cts. each).

22085. The Metropolitan Railroads of New York and London (R G–Began May 18—3 parts to date—15 cts. each).

SANITARY ENGINEERING.

21920. The Anderson System of Garbage Cremation. Ill. (E N–May 10.) 1500 w.

†22037. Sunshine and Microbes. Percy Frankland (N C–May.) 2800 w.

*22264. Modern Disinfecting Apparatus. Ill. William H. Ford (A H–June.) 2600 w.

22304.—75 cts. The Electrical Purification of Water. Thomas M. Drown (J N E W–June.) 3300 w.

*22526. Chemical Processes for the Treatment of Sewage (I & I–May 25.) 1500 w.

*22554. Sewers for Small Cities. M. Tschirgi, Jr. (P–June.) 1200 w.

Serials.

14839. Water Purification in America. Ill. (E N–Began Aug. 3—11 parts to date—15 cts. each).

19132. The Metropolitan Sewerage Systems of Massachusetts. Ill. (E N–Began Jan. 25—5 parts to date—15 cts. each).

19813. American Plumbing (D E–Began Feb. —4 parts to date—30 cts. each).

20194. Sewage Disposal. George E. Waring, Jr. (E R–Began March 3—4 parts to date—15 cts. each).

22506. Sanitary Plumbing (N B–Began June —1 part to date—30 cts).

STEAM ENGINEERING.

21943. Economy of Independent Auxiliary Pumps. Otto H. Mueller. (Eng–May 12.) 2200 w.

21949 An Economical Engine.—The Highest Duty Yet Reported in Mill Work. (B J C–May 12.) 600 w.

*21981. The Utilization of Anthracite Slack. (I S C–May 4.) 1600 w.

22102. Moisture in Steam.—Tests of Babcock and Wilcox Boilers at Cambridge Power Station of the West End Street Railway, Boston. (B J C–May 19.) 1500 w.

22103. Electricity for Engineers.—Locating and Overcoming Some Troubles. (B J C–May 19.) 1000 w.

*22113. The Grafton High Speed Engine. Edward W. Anderson (E–May 11.) 6000 w.

†22185. Notes on the Theory of Shaft Governors. Ill. Albert K. Mansfield (A S M E–June.) 3600 w.

†22186. The Theory of the Steam-Jacket; Current Practice. R. H. Thurston (A S M E–June.) 30000 w.

†22187. Mechanical Draft. Ill. William R. Roney (A S M E–June.) 2200 w.

†22188. Heat Units and Specifications for Pumping Engines. Albert F. Hall (A S M E–June.) 3000 w.

†22190. Results of Measurements of the Water Consumption of an Unjacketed 1600 Horse-Power Compound Harris-Corliss Engine. J. E. Denton, D. S. Jacobus and R. H. Rice (A S M E–June.) 1200 w.

†22191. The Saturation Curve as a Reference Line for Indicator Diagrams. R. C. Carpenter (A S M E–June.) 2000 w.

†22192. Corrosion of Steam Drums. Ill. James McBride (A S M E–June.) 2000 w.

†22193. Effect of Varying the Weight of Regenerator in a Hot-Air Engine. G. W. Bissell (A S M E–June.) 350 w.

†22194. Cylinder Proportions for Compound Engines Determined by Their Free Expansion Losses. Frank H. Ball (A S M E–June.) 3600 w.

†22195. First Stationary Steam Engine in America. F. R. Hutton (A S M E–June.) 1800 w.

†22198. Cost of an Indicated Horse Power. DeCourcy May (A S M E–June.) 1500 w.

†22199. A New Method of Compound Steam Distribution. F. M. Rites (A S M E–June.) 2000 w.

†22201. Results of Experiments with a Fifty Horse-Power Single Non-Condensing Ball and Wood Engine to Determine the Influence of Compression on the Water Consumption. D. S. Jacobus (A S M E–June.) 1000 w.

22204. Triple Expansion Steam Engines, Built by the Pupils of the Cincinnati Technical School. Ill. (A M–May 24.) 700 w.

22263. Wear and Tear in Boilers (B J C–May 26.) 1500 w.

22268. Objections to Pulverized Coal Fuel (Eng–May 26.) 800 w.

22314. Important Points for a Smoke Device (M G–May 26.) 500 w.

22315. Result of a Trial of a Horizontal Tubular Boiler (No. 3) Youth's Companion Building, Boston (M G–May 26.) 300 w.

*22327. Engine Trials in the Mechanical Laboratory of the University of Liège. V. Dwelshauvers-Dery (S J E–May.) 1200 w.

*22328. An Analytical Study of the Initial Condensation in Steam Engines. Lionel S. Marks (S J E–May.) 3000 w.

†22342. The Generation of Steam. Ill. A. C. Broucher and W. B. Broucher (Tech-1893-94.) 1800 w.

22350.—$1.25. Practical Application of Formulæ for Finding the Turning Effort on the Crank Shaft of an Engine. B. C. Bryan (J A N E–May.) 3000 w.

22368. High and Low-water Alarms.—An Explanation. W. H. Wakeman (A M–May 31.) 1200 w.

22376. The Generation of Steam by the Use of Blast Furnace Gases. J. Weidman Murray (Ir Age–May 31.) 1000 w.

22410. Testing the Commercial Value of Steam Coals. Charles A. Hague (E N–May 31.) 1100 w.

22428. Proper Size of a Safety Valve (B J C–June 2.) 1300 w.

22456. Remarks Concerning the Compound Engine. W. H. Wakeman (M G–June 2.) 700 w.

22460. Cylinder Ratios in Compound and Triple Expansion Engines. P. M. E. (Pr–June.) 900 w.

*22545. Liquid Fuel. G. Stockfleth, with Discussion (J S A–May 25.) 9000 w.

22565. Direct and Indirect Piping to Indicator. Edward J. Willis (A M–June 7.) 700 w.

22609. Some Boiler Tests. D. Ashworth (B J C–June 9.) 600 w.

22010. Underground Steam Pipes. — A Method of Trenching Them (B J C-June 9.) 400 w.

Serials.

13033. Practical Hints to Boiler-makers and Templaters. Ill. (M W-Began May 12, 1893 —10 parts to date—30 cts. each).

17823. Designing Corliss Gears. James Dunlop (P Eng-Began Nov. 24, 1893—8 parts to date—30 cts. each).

18169. Power Plant in the Realty Building. Ill. (E R-Began Dec. 16—3 parts to date—15 cts. each).

18986. Boiler Calculations. James F. Hobart (S M-Began Jan. 15—6 parts to date—15 cts. each).

19709. The Indicator and Its Diagrams. Ill. Charles Day (P Eng-Began Feb. 2—10 parts to date—30 cts. each).

20182. The Elements of Boiler-Making. Ill. C. E. Fourness (L E-Began March—4 parts to date—30 cts. each).

21141. High Speed Steam Engines. Ill. John Radinger (E M-Began April—3 parts to date—30 cts. each).

22266. Air Pumps and Condensers. E. A. Blackwell (Eng-Began May 26—2 parts to date —15 cts. each).

TELEPHONY AND TELEGRAPHY.

*21916. Edison and the Kinetoscope. Ill. W. E. Woodbury (S-May.) 1700 w.

21944. The Use of the Telephone on French Railroads. (Abstract.) G. Dumont (R G-May 11.) 900 w.

22061. Submarine Rapid Telegraphy and Telephony. Ill. (E W-May 19.) 1200 w.

22066. A New Transatlantic Cable (Sc A S-May 19.) 1800 w.

*22145. Telegraphs and Trade Routes in Persia. Henry L. Wells (J S A-May 11.) 8000 w.

*22146. Telephony Without a Wire. Ill. (E L-May 11.) 900 w.

*22147. Some Data on the Cost of Telephone Work in New York City (E L-May 11.) 1100 w.

22172. The Fiftieth Anniversary of the Telegraph. Ill. Theodore Waters (E N Y-May 23.) 600 w.

*22217. A Bit of Telephone History. Morgan Brookes (S R E N-May.) 1000 w.

22218. The Jubilee of the American Telegraph. Ill. (E E N Y-May 23.) 1600 w.

22219. Pupin's System of Resonating Conductors for Telegraphy and Telephony. Ill. (E E N Y-May 23.) 1200 w.

*22478. The Telephone of To-day. Ill. Herbert Laws Webb (N E M-June) 6500 w.

*22483. Description of the Electrical Type-Printers as Used by the Exchange Telegraph Company. Ill. F. Digby Latimer (E R L-May 25) 3800 w.

*22488. On the Effect of Leakage on Wave Propagation in Telegraph Wires; or, Mr. Oliver Heaviside's Theory Explained by Analogy. G. F. FitzGerald (El-May 25.) 2600 w.

22630. The Telegraph and Its Inventor. Ill. (E I-June.) 800 w.

MISCELLANEOUS.

*21905. The Commercial Relations between Cuba and the United States. E. Sherman Gould (E Mag-July.) 3000 w.

21930. Organization and Management of Engineering Schools. William Z. Ripley (E N-May 10.) 1800 w.

21951. Engineers as Inventors. Edward P. Thompson (I Age-May.) 1600 w.

21960.—$1.00. The Problems of Municipal Government. E. L. Godkin (An A A-May.) 9000 w.

21961.—$1.00. The Reform of our State Governments. Gamaliel Bradford (An A A-May.) 8500 w.

21962. The Economic Value of Art in Industry. Louis Prang (B C-May 12.) 900 w.

*21984. Calorific Intensity and Power of Carbon. James Noble (P Eng-May 4.) 1500 w.

*21987. Tasmania and the Forthcoming Hobart International Exhibition 1894-95. G. Collins Levey, with Discussion (J S A-May 4.) 11500 w.

*22019. The Relation of Mathematics to Engineering. John Hopkinson (E E L-May 4.) 6800 w.

†22032. On the Subdivision and Distribution of Artificial Sources of Illumination. William A. Anthony (T A I E E-May.) 1500 w.

22056. Monumental Art. F. T. Robinson (Ml N-May.) 1200 w.

22084. The Restoration of the Purdue Laboratory. Ill. (R G-May 18) 800 w.

Serials

18930. Carnot and Modern Heat. Oliver Lodge (Eng L-Began Jan. 5—12 parts to date —30 cts. each).

19052. Notes on the Manufacture of Ropes. Ill. W. C. Popplewell (P Eng-Began Jan. 12 —5 parts to date—30 cts. each).

20802. Measurement of High Temperatures. A. Humboldt Sexton (P Eng-Began March 24 —Ended May 18—5 parts—30 cts. each).

21472. Some American Inventors and Their Achievements (Inv-Began April 14—4 parts to date—30 cts. each).

21518. The Midwinter Fair. Ill. (E W-Began April 28—4 parts to date—15 cts. each).

21591. The Preservation of Wood. A. M. Villon (E R-Began April 28—2 parts to date—15 cts. each).

21763. Engineering Practice and Education. Gaetano Lanza (J F I-Began May—2 parts to date—45 cts. each).

21816. The Waste Lands of Australia. Ernest Favenc (A P R-Began March—2 parts to date—45 cts. each).

22446. The Covered Markets of Europe (E-Began May 25—1 part to date—30 cts).

THE·TECHNICAL·INDEX

A CATALOGUE OF LEADING ARTICLES PUBLISHED CURRENTLY IN THE TECHNICAL JOURNALS OF THE UNITED STATES AND GREAT BRITAIN.

THIS index has been very properly described as "the greatest step that has been taken in recent years towards systematizing work" for the engineer, the architect, the electrician, the railway manager, and the business man. The list of publications regularly indexed will show that it covers a world-wide range of the best technical literature, and all the articles are so conveniently classified under general headings, that within a few minutes, once a month, an active man can learn of everything of any importance that has been published during the month in relation to the subjects in which he is interested. In short, it is to the practical man just what Poole's celebrated index to periodicals has long been to the literary worker, but with this essential improvement—namely : that in addition to indicating *just when and where* leading articles have been published, *we undertake to supply copies of the articles themselves.* The unparalleled convenience and economy of this double service can readily be appreciated.

IN ordering articles from us, care should be taken to give the *number*, not the title alone. The price of a single article is 15 cents; those indicated by an asterisk (*), 30 cents, and by a dagger (†), 45 cents; and where the cost is above this, the price is given immediately after the number. In every case the price is closely regulated by the cost to us of a single copy of the publication from which the article is taken.

To avoid the inconvenience of small remittances and to cheapen the cost of articles to those who order frequently, we sell coupons at the rate of 15 cents each, or 15 for $2, 40 for $5, and 100 for $12.50. Each coupon is receivable in exchange for one 15-cent article ; those marked * require two coupons; those marked † require three coupons; and for the articles of higher price, one coupon for each 15 cents: thus, a 75c. article requires five coupons. Samples of these coupons *will be sent free* for examination. They need only a trial to demonstrate their great convenience and economy.

[In the body of the index only the initials of the journals quoted are given, and these can be readily identified by the following list of periodicals. Other abbreviations are: Ill=Illustrated. w=words.]

THE AMERICAN PRESS.

A........Arena. *m*.. $5. Boston.
AA......American Architect. *w*. $6. Boston.
An A A..Annals of Am. Academy of Political and Social Science. *b-m*. $6. Philadelphia.
A An.... American Analyst. *f*. $1. New York.
A Ar.... American Artisan. *w*. $2. Chicago.
A & B....Architecture and Building. *w*. $6. N. Y.
A B D....Architect, Builder and Decorator. *m*. $2. Minneapolis.
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A & N R..Army and Navy Register. *w*. $3. Wash'ton.
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A S .....Age of Steel. *w*. $3. St. Louis.
A S M E.Am. Soc. of Mec. Eng. *m*. New York.
B U W..Bul. of the Univ. of Wis.
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Ch.......Chautauquan. *m*. $2. Meadville, Pa.
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Cos.... ..Cosmopolitan. *m*. $1.50. New York.
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E R......Engineering Record. *w*. $5. New York.
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E W......Electrical World. *w*. $3. New York.

F........Forum. *m.* $3. New York.
F D......The Foundry. *m.* $1. Detroit.
F W......Fire and Water. *w.* $3. New York.
G & F....Garden and Forest. *w.* $4. New York.
G R......Good Roads. *m.* $1. New York.
I A......Inland Architect. *m.* $5. Chicago.
I Age....Inventive Age. *s-m.* $1. Washington.
Ir Age..Iron Age. *w.* $4.50. New York.
I I G.....Iron Ind. Gazette. *m.* $1.50. Buffalo.
I R W...India Rubber World. *m.* $3. New York.
I S F.....Industry. *m.* $2. San Francisco.
I T R....Iron Trade Review. *w.* $3. Cleveland.
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J A C S..Jour. Am. Chem. So. *m.* $5. Easton.
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M Rec....The Marine Record. *w.* $2. Cleveland.
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N P R...Nat. Popular Review. *m.* $2.50. Chicago.
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23113. A Reliable Method of Recording Variable Current Curves. Ill. A. C. Crehore (E N Y–June 27.) 4000 w.

23114. Reactance. Ill. Charles Proteus Steinmetz and Frederick Bedell (E N Y–June 27.) 1000 w.

23141. Electrical Resonance as Related to the Transmission of Energy. William A. Anthony, with Editorial (E E N Y–June 27.) 5200 w.

23142. The Factory and Apparatus of the Fort Wayne Electric Corporation. Ill. (E E N Y–June 27.) 5500 w.

*23226. Experiments on Brown's Alternating Current Motor. Riccardo Arno (E R L–June 22.) 600 w.

*23228. Cooking by Electricity (E R L–June 22.) 2200 w.

*23232. Electrolytic Electricity Meters (I & I–June 22.) 2500 w.

*23236. On the Finding of Faults in Coils Wound on Conducting Bobbins. Albert Campbell (El–June 22.) 600 w.

*23237. A New Phenomenon Observed in the Passage of Electricity Through Badly Conducting Liquids. Ill. O. Lehmann (El–June 22.) 1900 w.

*23238. Electricity in the Kitchen (El–June 22.) 1600 w.

*23442. Modern Electro-Chemical Theory and its Bearing upon the Practice of the Future. Dr. Ostwald, with Editorial (El–June 29.) 4500 w.

*23455. Electrical Distribution by Alternating Currents. Editorial (E R L–June 29.) 1300 w.

*23457. Rear-Admiral Fleuriais's Electric Log. Ill. (E R L–June 29.) 900 w.

Serials.

21396. Coming Developments in Electricity. George D. Shepardson (E A–Began April 21—4 parts to date—15 cts. each).

22059. Practical Notes on Dynamo Calculation. Alfred E. Weiner (E W–Began May 19—8 parts to date—15 cts. each).

22361. Switzerland as the Present Electrical Centre of Europe. Ill. Frederick Bathurst (E W–Began June 2—Ended June 30—5 parts—15 cts. each).

22490. A Method for the Treatment of Rotating or Alternating Vectors, with an Application to Alternate Current Motors. Galileo Ferraris (El–Began May 25—Ended June 15—4 parts—30 cts. each).

22947. The Work of Hertz. Oliver Lodge (N–Began June 7—2 parts to date—30 cts. each).

23439. On Impulsive Current—Rushes in Inductive Circuits. Alfred Hay (El–Began June 29—1 part to date—30 cts).

ELECTRIC POWER.

22774. The New Stanley-Kelley-Chesney Alternating Current Generator. Ill. (E N Y–June 13.) 3800 w.

22794. Systems of Transmitting Electric Power. Gisbert Kapp (C Eng–June.) 900 w.

22795. Versatility of the Electric Motor (C Eng–June.) 700 w.

*22895. The Behavior of Single-Phase-Synchronous Motors. C. E. Hewitt and James Lyman (S J E–June.) 1500 w.

23023. Distribution of Electrical Power. W. H. Adams (E M J–June 23.) 2000 w.

†23026. Some Practical Hints in Dynamo Design. Gilbert Wilkes (B U W–No. 2.) 6500 w.

23089. Electrical Power Transmission at West Pullman, Ill. Ill. (W E–June 23.) 1600 w.

23121. The Adoption of Electric Power in Steel Works. Clifford C. Smith (Ir Age–June 28.) 2500 w.

†23152. A Twelve-Mile Transmission of Power by Electricity. Ill. Thomas H. Leggett (Tr A M E–July.) 7500 w.

23303. Power Transmission at the Paris Exposition of 1900. Editorial (E E N Y–July 4.) 1000 w.

23337. Experiments on Two-Phase Motors. Ill. Dr. Louis Duncan, S. H. Brown, W. P. Anderson and S. Q. Hayes (E R N Y–July 4.) 2600 w.

†23342. The Electric Long Distance Transmission Plant at Portland, Ore. Ill. (S R J–July.) 3800 w.

*23459. Central Stations for Electric Energy in Germany (E R L–June 29.) 1200 w.

Serials.

22570. On the Measurement of the Power of Polyphased Currents. Alexander D. Lunt (E W–Began June 9—3 parts to date—15 cts. each).

GAS ENGINEERING.

22786. Artificial Fuel Gas. Henry Wurtz (Sc A S–June 16.) 4300 w.

22840. Purification of Gas. Edward C. Jones, with Discussion (P A–June 15.) 4000 w.

22841. Small Things Around a Small Works. M. C. Osborn, with Discussion (P A–June 15.) 1600 w.

22842. How We Do at Our House. T. R. Parker, with Discussion (P A–June 15.) 2400 w.

22843. The Relations of Lighting Companies to the Public. C. W. Quilty (P A–June 15.) 1200 w.

22844. Proper Books of Record. John A. Britton, with Discussion (P A–June 15.) 6300 w.

22845. Foes to Our Gas Mains and Service Pipes. John Kempf, Jr., with Discussion (P A–June 15.) 2400 w.

*22873. Report on Trials of a Crossley Gas Engine at Messrs. Wallaert Frères' Mill, Lille. Aime Witz (Eng L–June 8.) 1200 w.

*22930. Notes on the Enrichment of Coal Gas, More Particularly Bearing Upon Enrichment by the Peebles Oil-Gas Process. Ill. S. Glover (J G L–June 5.) 4200 w.

*22931. The Introduction, Development and Practical Working of Oxy-Oil Gas Process at the Huddersfield Gas-Works. Ill. W. R. Herring (J G L–June 5.) 4600 w.

*22932. Discussion on the Papers of Messrs. Bell, Glover and Herring (J G L–June 5.) 4000 w.

*22969. Relation of Carburetted Water Gas to the European Gas Industry in 1894. A. M. Paddon (J G L–June 12.) 3000 w.

*23047. Mechanical Appliances at the Manchester Corporation Gas Works. Ill. (I & I–June 15.) 3800 w.

*23058. Residuals and Their Value. James Ferrier (G E M–June 11.) 1000 w.

23066. Motors for Lighting, or Generator Gas vs. Engines with Saturated or Superheated Steam. Bryan Donkin (A G L J–June 25.) 6000 w.

*23068. The Crisis in the Gas Supply. Editorial (Eng L–June 15.) 900 w.

23163. Apparatus for Analyzing Gases. Ill. Patent of E. A. Uehling (E M J–June 30.) 1000 w.

*23166. Inaugural Address of John West (J G L–June 19.) 7800 w.

*23167. Street Lighting with Incandescent Gas Burners (J G L–June 19.) 3000 w.

*23168. The Profit Sharing System. George Livesey (J G L–June 19.) 1400 w.

23172. Some Electric Plants in Chicago Driven by Gas Engines. Ill. (W E–June 30.) 900 w.

*23229. Gas Engine Power for Private and Public Electric Supply. Ed. C. de Segundo (E R L–June 22.) 3500 w.

23256. Mr. A. Crova's Address before the Association of French Gas Engineers (A G L J –July 2.) 6000 w.

*23346. Illuminating Power and Illuminating Effect. Thomas Newbigging (J G L–June 26.) 3800 w.

*23347. A Plea for Differential Charges for Gas. George Anderson (J G L–June 26) 1500 w.

*23348. An Improvement in the Construction of Atmospheric Burners. C. B. Voisey (J G L–June 26.) 2500 w.

*23349. A First Season's Experience of Carburetted Water Gas. J. Stelfox (J G L–June 26.) 5600 w.

*23350. The Profit-Sharing System—Letter from George Livesey (J G L–June 26.) 1000 w.

*23450. Steam Applied as an Aid to the Revivification of Oxide of Iron in Situ. Ill. Frederick G. Dexter (G W–June 30.) 3800 w.

Serials.

13881. Labor Saving Appliances in Gas Works (I & I–Began June 16, 1893—Ended June 8, 1894—3 parts—30 cts. each).

20417. Gas Stoves and Ventilation. Edward J. Smith (Pl D–Began March—Ended June—4 parts—30 cts. each).

21052. The Development of the Gasholder. Alex. Mc I. Clelland (J G L–Began March 27—Ended June 12—5 parts—30 cts each).

21760. On Gas Burners, Gas Pressure Regulators and Governor Burners, Gas Globes and Globe Holders, and Gas Fixtures. William Paul Gerhard (J F I–Began May—Ended July—3 parts—45 cts. each).

22714. Recent Developments in Gas Manufacture (I & I–Began June 1—1 part to date—30 cts).

23209. Recent Improvements in the Utilization of Gas (G W–Began June 23—1 part to date—30 cts).

23282. The Gas and Electricity Supply of Blackpool. William Chew (E E L–Began June 22—Ended June 29—2 parts—30 cts. each).

23473. Distribution of Gas. J. P. Gill (A G L J–Began July 9—1 part to date—15 cts).

HYDRAULICS.

22756. Arid America's Opportunity (A S–June 9.) 1100 w.

†22778. The Proposed Nile Reservoir. I. The Devastation of Nubia. J. P. Mahaffy. II. The Submergence of Philæ. Frank Dillon (N C–June.) 5600 w.

22792. Acadian Dikes. Ill. (C Eng–June.) 1800 w.

22805. Reconstruction of the Water-Works of Alliance, O. Ill. L. L. Tribus (E N–June 14.) 2800 w.

*22826. Notes on Water Power Equipment. A. W. Hunking, with Discussion (J A E S–April.) 8000 w.

22847. Damming the Nile—Philæ. John Fowler (B C–June 16.) 2000 w.

22911. The Old Pumps and Wells of New York. (From the Evening Post.) (A & B–June 16.) 1600 w.

*23093. The Nile Reservoir. Editorial (E–June 15.) 1800 w.

*23094. Power Transmission at Periyar (E–June 15.) 1600 w.

23104. The Water Power Revival (A S–June 23.) 600 w.

†23149. Artesian Well Prospects in Eastern Virginia, Maryland and Delaware. N. H. Darton (Tr A M E–July.) 6800 w.

23280. Laying a Sixteen-Inch Main Across a Rocky Mill Stream and over a Dam. George F. Chace (F W–June 30.) 1350 w.

23283. Irrigation in California. Ill. S. P. Adams (M & B–May.) 1500 w.

23312. The Irrigation of Lawns. Ill. (Sc A–July 7.) 350 w.

23353. Submerged Water Works Intake, Whiting, Ind. C. McLennan (E N–July 5.) 500 w.

23389. Notes on an Insecure Reservoir Bottom. Louis L. Tribus (E R–July 7.) 1000 w.

Serials.

18676. The Pumping Engine; Its Many Points, Faults and Peculiarities. Ernest W Naylor (F W–Began Jan. 6—16 parts to date—15 cts. each).

21433. Glasgow Water Works. Ill. (E–Began April 13—6 parts to date—30 cts. each).

22559. Irrigation by Pumping. Ill. Alfred Chatterton (I E–Began May 5—3 parts to date—45 cts. each).

22670. The Regulation of the Iron Gate and Other Cataracts on the Lower Danube. Ill. Bela von Gonda (Eng L–Began June 1—2 parts to date—30 cts. each).

23253. Water Pressure Engines. S. H. Hollands (P Eng–Began June 22—Ended June 29—2 parts—30 cts. each).

23279. What a Water Supply Engineer Can Do in the Fire Department. James E. Tryon (F W–Began June 30—2 parts to date—15 cts. each).

23375. The Problem of Future Water Supplies for New York, Philadelphia, Brooklyn and

Jersey City. Peter Milne (F W–Began July 7—1 part to date—15 cts).

INDUSTRIAL CHEMISTRY.

†22777. Modern Explosives. Wentworth Lascelles Scott (N C–June.) 5000 w.

*22919. The Industrial Electrolysis of Fused Salts. Ill. Bertram Blount (E P–June.) 2200 w.

†23108. Some Sources of Error in Our Methods of Determining Potash in Fertilizers and German Potash Salts. N. Robinson (J A E S–June.) 2800 w.

†23110. On the Estimation of Sulphur in Pyrites. Thomas S. Gladding (J A E S–June.) 2000 w.

†23111. Electrolytic Separations. Edgar F. Smith and Henry E. Spencer (J A E S–June.) 1400 w.

†23411. On the Analysis of American Refined Copper. Harry F. Keller (J F I–July.) 1200 w.

Serials.

15176. The Chemical and Physical Examination of Portland Cement. Thomas B. Stillman (J A E S–Began April, 1893—Ended June, 1894—4 parts—45 cts. each).

INDUSTRIAL SOCIOLOGY.

*22647. The Prevailing Jealousy of Wealth. William Nelson Black (E Mag–Aug.) 3000 w.

*22678. Compensation for Losses by Riots (I & I–April 27.) 1200 w.

22681. The Padrone Nuisance. Edward E. Hale (B C–June 9.) 1200 w.

22713. Rate Wars and Strikes.—A Study. William S. Huntington (R A–June 8.) 900 w.

22719. Why Was There a Strike? (B D–June 9.) 1000 w.

22720. Day-Dreams of Utopia (B D–June 9.) 1000 w.

22746.—75 cts. The Homestead Strike. Edward W. Bemis (J P E–June.) 9500 w.

22749.—75 cts. The Army of the Commonweal. T. B. Veblen (J P E–June.) 1500 w.

†22799. The New Factory Bill: As It Affects Women. Evelyn March-Phillipps (F R–June.) 5400 w.

22887. Industry and Competition (B D–June 16.) 900 w.

22888. Incipient Revolution (B D–June 16.) 900 w.

†22948. The Meaning of Corporations and Trusts. Logan G. McPherson (P S M–July.) 11000 w.

22956.—$1. The Future Problem of Charity and the Unemployed. J. G. Brooks (An A A–July.) 10000 w.

22957.—$1. Peaceable Boycotting. Chester A. Reed (An A A–July.) 7200 w.

22958.—$1. Rent and Profit. C. W. Macfarlane (An A A–July.) 5000 w.

22960. Miners' Unions. Editorial (M I T–June 14.) 1100 w.

22965. Garrett on Capital and Labor (Ir Age–June 21.) 1700 w.

*22970. Eight Hours for Work.—Comments on book by John Rae (J G L–June 12.) 2500 w.

23038. Is It Law or Chaos? (B D–June 23.) 900 w.

*23042. Coxeyism and Its Commonwealers (R of R–June 15.) 9500 w.

*23092. The Royal Commission on Labor. Editorial (E–June 15.) 2100 w.

23102. The Latest "Trust." A. B. Salom (I I G–June.) 1200 w.

23115. The Cripple Creek Strike. Editorial (Min R–June 14.) 1000 w.

*23159. The Downfall of Coxeyism. Shirley Plumer Austin (Ch–July.) 3200 w.

*23208. Strikes and Lockouts in 1892 (C G–June 22.) 1200 w.

*23218. "Coxeyism": A Character Sketch. Ill. W. T. Stead (R of R–July.) 6000 w.

*23219. A Talk with Samuel Gompers, the Labor Leader (R of R–July.) 2400 w.

*23220. Strikes and Lock-Outs. Editorial (Eng L–June 22.) 1600 w.

*23255. The History of Trades' Unionism.—Review of book by Sidney and Beatrice Webb (B–June 23.) 2000 w.

23278. Industrial Turmoils (B D–June 30.) 900 w.

†23381. The Crusade of the Unemployed. Henry Frank (A–July.) 2300 w.

23394. The Panacea—Relating to Strikes, etc. Frederick E. Goodrich (B C–July 7.) 1000 w.

*23415. Final Report of the Royal Commission on Labor. Editorial (E–June 29.) 2200 w.

*23420. Recommendations of the Royal Commission on Labor (C G–June 29.) 7200 w.

LANDSCAPE ENGINEERING.

22770. Water Courses in their Relation to the Public (G & F–June 13.) 1200 w.

22771. American Parks—Druid Hill, Baltimore. M. C. Robbins (G & F–June 13.) 1100 w.

23112. "Nature and the Rich" (G & F–June 27.) 1500 w.

23302. Art and Nature (G & F–July 4.) 1400 w.

†23382. Public Parks and Playgrounds: A Symposium. Compiled by Thomas E. Will (A–July.) 6000 w.

MARINE ENGINEERING.

*22661. The Suez Canal and Shipping (E–June 1.) 1350 w.

*22669. The Proposed Birmingham Ship Canal. Ill. (Eng L–June 1.) 8200 w.

*22709. The New German and Austrian Shipping Combination (Tr–June 1.) 1200 w.

22798. Free Admission to American Registry of Ships Built in Foreign Countries.—Views of the Minority (Sea–June 14.) 3300 w.

*22831. British Shipowners and the British Flag.—A Movement at Cardiff to Register Abroad (F'y–June 8.) 1600 w.

*22866. The Glasgow and South-Western

Railway Company's Clyde Steamers (E–June 8.) 1800 w.

*22867. The Manchester Ship Canal. Editorial (E–June 8.) 3800 w.

22906. Test Borings, Outer Diamond Shoals. Ill. (E R–June 16.) 2000 w.

*22912. Ocean Mail Competition (R P L–June 1.) 1900 w.

*22913. Royal Opening of the Ship Canal (R P L–June 1.) 3500 w.

*22929. International Congress on Inland Navigation (Tr–June 8.) 1800 w.

†22954. Apprentice Life at Sea. John G. Rowe (W R–June.) 1600 w.

22977. Skillful Engineering.—A Lighthouse off Hatteras (Sea–June 21.) 1100 w.

22989. Water-Jet Propulsion on the River Elbe, Germany—with Editorial. Ill. (E N–June 21.) 4500 w.

*23031. Manchester Ship Canal.—Threatened Disaster.—Speech of Sir John Harwood (F'y–June 15.) 2900 w.

23037. American Ships and American Coal (B D–June 23.) 700 w.

*23081. A Coracle, or Hide-Boat. Ill. (I C B–June 15.) 1500 w.

*23082. Clinker and Canoe. Ill. (I C B–June 15.) 1000 w.

*23086. The Ships of Ancient Greece (Tr–June 15.) 2500 w.

23127. The French Aluminum Yacht Vendenesse (Sc A–June 30.) 1000 w.

23133. Queen of Steam-boats.—The Priscilla. Ill. (Sea–June 28.) 3000 w.

23134. The Leading Ship-building Plants of the Atlantic Coast, with Editorial. Ill. (Sea–June 28.) 6400 w.

†23147. Superstitions of the Sea. Ill. J. D. Jerrold Kelley (C M–July.) 4800 w.

*23201. The Situation at Hull (Tr–June 22.) 1300 w.

23214. Antarctica, or the Hypothetical Southern Continent. Ill. A. W. Greely (Cos–July.) 3200 w.

*23225. Marine Dangers (E–June 22.) 1400 w.

23272. The Use of Compressed Air in Raising Vessels.—Raising the "Plymouth" (E R–June 30.) 900 w.

23287.—50 cts. Steamship Northwest. Ill. (M R C–June 30.) 13000 w.

23330. Sault Ste. Marie, Mich. Ill. George A. Cady (G R–July.) 1200 w.

†23413. Shortening the Time for Correct Sounding. F. M. F. Cazin (J F I–July.) 2000 w.

*23418. Liverpool and the Ship Canal. Editorial (E–June 29.) 2000 w.

*23430. The Proposed Canadian Line of Mail Steamers (Tr–June 29.) 1000 w.

23472. A House Boat.—Owned by Pierre Lorillard (From the N. Y. Sun.) (Eng–July 7.) 700 w.

Serials.

16636. Marine Engine Design (M W–Began Oct. 6—11 parts to date—30 cts. each).

21969. The Shark and the Sailor. A. L. V. E. (I E–Began April 14—6 parts to date—45 cts. each).

MECHANICAL ENGINEERING.

*22653. The Early Lives of Great Inventors. Leicester Allen (E Mag–Aug.) 2500 w.

22682. Lubricating Oils. A. C. J. Charlier (O P D R–June 11.) 1800 w.

*22686. Joints for Pipes (I C B–June 1.) 1500 w.

*22703. Chains v. Ropes for Lifting Machinery. Ill. Editorial (P Eng–June 1.) 1600 w.

22791. Presidential Address of Eckley B. Coxe (A M–June 14.) 6200 w.

22804. Turning and Lifting Machinery for 450 feet Swing Span, Alton Bridge. Ill. J. H. Warden (E N–June 14.) 1800 w.

†22828. A Simple Water Resistance Prony Brake. F. M. Leavitt (S In–April.) 800 w.

†22830. The Pneumatic Pyrometer. Ill. Edward E. Uehling (S In–April.) 3000 w.

*22851. Samuel Crompton: Inventor. M. E. Bradshaw-Isherwood (Inv–June 9.) 3000 w.

*22896. Experiments to Determine the Power Absorbed by Shafting, when Transmitting Varying Loads. Lionel S. Marks and S. Henry Barraclough (S J E–June.) 600 w.

22973. A Pattern System. Walter B. Snow (A M–June 21.) 2400 w.

23003.—$1.50. Cableways. Ill. Spencer Miller (T C E–April.) 4500 w.

23018. About Binders and Fastening Pulleys (B J C–June 23.) 1000 w.

23098.—75 cts. A New Torsion Machine. Ill. Edward F. Miller (T Q–Dec.) 1500 w.

23099.—75 cts. The Efficiency of Jack-Screws. Ill. Edward F. Miller and William A. Johnston (T Q–Dec.) 900 w.

23119. An Intricate Wire Forming Machine—Designed by Robert C. Manville. Ill. (Ir Age–June 28.) 1500 w.

23129. What Has Economy to Do with Compressed Air? Frank Richards (A M–June 28.) 900 w.

23186. A Mechanical Fluid—Novel Method of Taking Up Wear of Bearing. Ill. (B J C–June 30.) 800 w.

*23210. The Oil Engine Trials (Irm–June 23.) 2700 w.

*23231. Chains and Wire Ropes for Cranes (I & I–June 22.) 1400 w.

*23239. On the Whirling and Vibration of Shafts. Stanley Dunkerley (El–June 22.) 2000 w.

*23250. Crane Chain Accidents. Editorial (P Eng–June 22.) 1600 w.

†23290. Spiral Goniometry in Its Relation to the Measurement of Activity. Ill. Carl Barns (A J S–July.) 3000 w.

23326. Style and Finish in Mechanical Work (A M–July 5.) 1300 w.

23327. Plates of Uniform Strength. Albert E. Guy (A M–July 5.) 1200 w.

23328. Testing Indicator Springs. Edward J. Willis (A M–July 5.) 1700 w.

†23345. Lubricating Oils (I E–June 2.) 1200 w.

23351. The Pneumatic Tube System of the City Press Association of Chicago, Ill. W. L. Stebbings (E N–July 5.) 2000 w.

†23407. The Manufacture of Very Accurate Straight Edges. Ill. F. L. O. Wadsworth (J F I–July.) 6500 w.

23478. Report on Special Shop Tools (R A–July 6.) 5000 w.

Serials.

17362. Arithmetic of the Screw and of Symmetrical Rings. Ill. Leicester Allen (A M–Began Nov. 16—4 parts to date—15 cts. each).

17900. Machine Shop Milling Practice. Ill. Horace L. Arnold (A M–Began Dec. 7—10 parts to date—15 cts. each).

18044. Motive Power and Gearing. E. Tremlett Carter (El–Began Dec. 1—16 parts to date—30 cts. each).

20900. Mechanical Drawing. Ill. (T–Began April 1—5 parts to date—15 cts. each).

22414. Oil and Petroleum Engines. H. M. Waynforth (M W–Began May 25—Ended June 22—4 parts—30 cts. each).

METALLURGY.

*22652. Electric Welding and Metal-Working. Ill. Herman Lemp (E Mag–Aug.) 3000 w.

*22698. Pewter. Ill. J. Starkie Gardner, with Discussion (J S A–June 1.) 18000 w.

*22727. The Smithfield Iron Works, Leeds. Ill. (R W–June.) 2700 w.

*22769. Some Improvements in Treating Minerals for the Wet Extraction of Gold and Silver. John Storer (A M S–May 12.) 1600 w.

22797. The Strength and Resilience of Structural Cast Iron. J. B. Johnson (Ir Age–June 14.) 3000 w.

22835. The Iron Works of Samaca, Colombia. Thomas B. Nichols (E M J–June 2.) 1600 w.

*22880. Staffordshire as a Steel Producing District (C G–June 8.) 1500 w.

*22883. Unemployed Iron Making Plant (I C T–June 8.) 1000 w.

*22884. The Regulation of Ironworkers' Wages (I C T–June 8.) 1300 w.

*22945. Consolidating Steel Ingots. J. L. Sebenius. (From Cassier's Magazine) (P Eng–June 8.) 1400 w.

22961. The Cyanide Mill in the Black Hills (M I T–June 14.) 1000 w.

22967. Steel Manufacture in the South. J. B. Nau (Ir Age–June 21.) 3600 w.

22974. Cupola Practice. Herbert M. Ramp (A M–June 21.) 1600 w.

23004.—$1.50. An Instructive Eye-Bar Test. A. C. Cunningham, with Discussion (T C E–April.) 8300 w.

23015. Sentinella's Sodium Flux for Iron Founders. Walter J. May (A M & I W–June 22.) 500 w.

23016 On the Determination of Loss in Iron Ore Concentration. Walter J. May (A M & I W–June 22.) 700 w.

*23050. The Metric System Applied to the Iron and Steel Trades. Walter J. May (P Eng–June 15.) 1000 w.

23120. Progress in Galvanizing. Ill. (Ir Age–June 28.) 1700 w.

23124. Electric Smelting, Germany. Frank H. Mason (E W–June 30.) 1500 w.

†23150. The Manufacture of Open-Hearth Steel in Sweden. Ill. Erik Gison Odelstjerna (Tr A M E–July.) 6700 w.

23181. Coke Making in the South. (Extract.) Richard Thomas (A M & I W–June 29.) 1700 w.

23182. Jigging Ores. Walter J. May (A M & I W–June 29.) 700 w.

*23202. Rolling Rods Directly from Small Ingots (C G–June 22.) 1800 w.

*23205. The Eight-Hour Day at Cleveland Blast Furnaces (C G–June 22.) 1400 w.

*23235. German Competition in the Iron and Steel Industries.—Report of Special Committee to the Board of Management (I C T–June 22.) 4000 w.

23305. Do Iron and Steel Crystallize in Service? Paul Kreuzpointner (Ir Age–July 5.) 4000 w.

23384. The Microscopic Metallurgy of Copper Alloys. Ill. M. Guillemin (E M J–July 7.) 1300 w.

23385. Dressing Zinc and Lead Ores in Southwest Missouri and Southeast Kansas. George T. Cooley (E M J–July 7.) 1200 w.

*23400. Improvements in Rolling Mill Plant. Ill. (Eng L–June 29.) 500 w.

*23428. Lead Smelting in the Ore Hearth in Scotland. Ill. A. H. Sexton (I & I–June 29.) 1200 w.

23436. The Iron Works of Samaca, Colombia (Min R–June 21.) 2000 w.

23461. Vast Rolling Mills in China (I W–July 5.) 600 w.

Serials.

21201. Lacquer and Bronze Work. William Norman Brown (Pl D–Began April—3 parts to date—30 cts. each).

21369. Press Work of Sheet Metals. Ill. Oberlin Smith (Ir Age–Began April 19—2 parts to date—15 cts. each).

21715. Practical Blacksmithing. James F. Hobart (T–Began May 1—3 parts to date—15 cts. each).

21814. Plate Moulding. Ill. J. Horner (P Eng–Began April 27—4 parts to date—30 cts. each).

22710. Science for Ironmongers (Irm–Began June 2—3 parts to date—30 cts. each).

22790. Foundry Inventiveness. Ill. S. Bolland (Am–Began June 14—2 parts to date—15 cts. each).

22854. The Dry Assay of Ores (I & I–Began June 8—4 parts to date—30 cts. each).

23162. Iron-Making at Birmingham, Ala. Edmund C. Pechin (E M J–Began June 30—2 parts to date—15 cts. each).

MILITARY ENGINEERING.

*22651. The Modern Battle-Ship as a Fighting Machine. George W. Melville (E Mag–Aug.) 3000 w.

*22671. Warships and Critics. Editorial (Eng L–June 1.) 1900 w.

*22680. The Destructive Effects of Small Projectiles (N–May 31.) 1700 w.

*22697. Dowe's Bullet-Proof Cuirass in London (Inv–June 2.) 3500 w.

*22852. The Maxim-um "Joke" and a Minimum of Satisfaction; or, Bullet-"Spoof" and Other Cuirasses, Involving Curses and Cupidity (Inv–June 9.) 4300 w.

*22871. The United States Armor-Plate Scandal. Editorial (Eng L–June 8.) 1300 w.

*23001. The Gettysburg Week. Philip Schaff (Sc M–July.) 6000 w.

23012. Character of the Armor Manufactured at the Carnegie Steel Works, as Demonstrated by Recent Trials. Ill. (A & N J–June 23.) 6000 w.

*23085. The Latest Phases of the Bullet Proof Epidemic and Disclosures Referring to Certain Patents (Inv–June 16.) 4500 w.

†23107. How to Make West Point More Useful. F. A. Mitchel (N A R–July.) 2100 w.

23126. Recent Trials of Rapid Firing Six Pounder Machine Guns. Ill. (Sc A–June 30.) 600 w.

23128. Bombs and Infernal Machines. Ill. Lieut. Col. Hennebert, in La Nature (Sc A S–June 30.) 3800 w.

†23144. The Evolution of a Battleship. Ill. Albert Franklin Matthews (C M–July.) 6500 w.

†23145. "The Star Spangled Banner." John C. Carpenter (C M–July.) 3000 w.

23153.—75 cts. American Military Roads and Bridges. P. S. Michie (J M S I–July.) 3500 w.

23154.—75 cts. The Nicaragua Canal in Its Military Aspects. William K. Hamilton (J M S I–July.) 4000 w.

23155.—75 cts. Portable Intrenching Tools for Infantry. Ill. W. C. Wren (J M S I–July) 5200 w.

*23161. The Restoration of Joan of Arc. M. Munier-Jolain (Ch–July.) 1800 w.

23213. Some Rare Napoleonic Medals. Ill. J. Howe Adams (Cos–July.) 3000 w.

23215. Louis Kossuth. Ill. Madam Adam (Cos–July.) 3300 w.

23274. Our Nation's Defenses. William P. Craighill (E R–June 30.) 6000 w.

23310. The Stability of War Ships (Sc A–July 7.) 1000 w.

23311. The Lengthening of the Gunboats Machias and Castine. Ill. (Sc A–July 7.) 900 w.

*23366. Transportation of a Torpedo Boat from Toulon to Cherbourg. Ill. M. Partiot (A E R J–July.) 4000 w.

*23398. The Fastest Ship in the World—the "Daring." (Eng L–June 29.) 1500 w.

*23416. The New Thornycroft Torpedo Vessel. Editorial (E–June 29.) 3000 w.

23462. Torpedo Boat "Ericsson." Ill. (I Age–July) 800 w.

23480. Errant Ingenuity and Devious Devices.—Tricks that Defy Inspectors.—Armor Plates. B. F. Spalding (A S–July 7.) 3000 w.

Serials.

20214. A General Review of Existing Artillery. Gaston Moch (J M S I–Began March—3 parts to date—75 cts. each).

21582. The New Regulations for Field Fortifications in the German Army. Ill. Thomas C. Patterson (J M S I–Began May—2 parts to date—75 cts. each).

21991. The New Spanish Belted Cruisers. Ill. (E–Began May 4—4 parts to date—30 cts. each).

MINING.

*22645. Colorado's New Gold Camps. Ill. Arthur Lakes (E Mag–Aug.) 3500 w.

†22666. Peculiarities of the Mystic Coal Seam. H. Foster Bain (A G–June.) 1200 w.

†22667. The Origin of Anthracite. Charles Rollin Keyes (A G–June.) 1200 w.

22699. The Elk Garden and Upper Potomac Coal Fields of West Virginia. Joseph D. Weeks (A M & I W–June 8.) 2700 w.

*22735. Russian Coalfields and Their Production (C G–June 1.) 3800 w.

*22736. The Southeastern Coalfield (C G–June 1.) 800 w.

*22737. The Historical Hottenguer Shaft of the Epinac Colliery. M. Nongarède (C G–June 1.) 3200 w.

*22738. California Coal. J. Coventry I'Anson (C G–June.) 1500 w.

*22753. The Lake Superior Sandstones. Letter from H. G. Rothwell (S–June.) 1200 w.

*22761. Three Interviews—Opinions About Coolgardie (A M S–April 28.) 3800 w.

*22765. The Coolgardie Goldfield (A M S–May 5.) 3500 w.

22787. Deep Boring near Freidstadt, Austria. R. Nelson Boyd (Sc A S–June 16.) 6800 w.

22812. Mines and Mills of Northern California. Carrol G. Sprague (M S P–June 9.) 2000 w.

22821. Zinc Ore Deposits of New Mexico. (Abstract.) William P. Blake (O P D R–June 18.) 1700 w.

22834. The Amy and Silversmith Decision Again. R. W. Raymond (E M J–June 16.) 1200 w.

*22862. British Coal for the United States (C T J–June 9.) 1000 w.

*22875. Economical Development of the Rhenish-Westphalian Coalfield. (Extract.) Dr. Reismann-Grone and E. Schrödter (C G–June 8.) 4200 w.

*22876. Income Tax on Mines and Quarries (C G–June 8.) 8500 w.

*22877. The Working of Thick Coal Seams by Longwall. M. E. (C G–June 8.) 800 w.

*22878. The Pacific Coast Coalfields (C G–June 8.) 1100 w.

*22879. Steel v. Timber for Supporting the Roof of Mines. (Extract.) C. C. Ellison (C G–June 8.) 1400 w.

*22881. Main Doors as Factors in the Ventilation of Coal Mines Under the Effects of an Explosion of Gases. Ill. (C G–June 8.) 900 w.

*22882. Kolar Goldfields (Min W–June 9.) 1700 w.

†22951. The Miner's Eight-Hour Question. Walter Trevelyan Thomson (W R–June.) 3200 w.

22962. Geology of the Cripple Creek Gold Mining District, Colorado. Whitman Cross (M I T–June 14.) 4800 w.

22985. Folsom's Former Gold Yield. (E. C. R. in the Sacramento Bee) (M S P–June 16.) 1200 w.

22991. Florida Phosphate Industry (M R–June 22.) 1300 w.

23039. Coal in the South (B D–June 23.) 950 w.

*23051. The Shropshire Coalfields (C G–June 15.) 2500 w.

*23052. On the Proportion of Carbon Dioxide (Chokedamp) in Air Which Is Extinctive to Flame. Frank Clowes (C G–June 15.) 1500 w.

*23053. The Mineral Development of Nova Scotia. (Abstract.) E. Gilpin (C G–June 15.) 1600 w.

*23054. The Probable Range of the Coal Measures in Southern England. W. Boyd-Dawkins (C G–June 15.) 3200 w.

*23055. Salt Deposits in the Isle of Man. (Abstract.) W. Boyd Dawkins (C G–June 15.) 1000 w.

*23056. Electrical Transmission of Power with Diphase Currents for Mining Purposes (C G–June 15.) 800 w.

*23057. The Salt Mines of Carrick-Fergus. Alexander Miscampbell (C G–June 15.) 1300 w.

*23087. The Rating of Mines. E. J. Castle (I C T–June 15.) 4000 w.

23116. Alaska Gold Mines (Min R–June 14.) 1700 w.

23132. Phosphate Rock.—An Official Report by the United States Geological Survey (M R–June 29.) 1600 w.

23143. The Commercial Aspect of Coal Mining. (Extract.) G. A. Mitchell (C M R–June.) 2000 w.

†23148. Mine Explosions Generated by Grahamite Dust.—Discussion of paper by William Glenn (Tr A M E–July.) 3300 w.

†23151. The Elk Garden and Upper Potomac Coal-Fields of West Virginia. J. D. Weeks (Tr A M E–July.) 2800 w.

23185. Facts About Metals.—Quicksilver and How It Is Mined, etc. (B J C–June 30.) 1800 w.

*23188. The Goldfields of British Guiana (B T J–June.) 1200 w.

*23191. The Deadlock in the Coal Trade Controversy (C T J–June 23.) 1400 w.

*23204. Compressed Air for Transmission of Power in Coal Mines. M. E. (C G–June 22.) 800 w.

*23206. The Shropshire Coalfields and Their Surroundings. John Randall (C G–June 22.) 1000 w.

23277. New Markets for Coal (B D–June 30.) 900 w.

23286. Gold in Quartzite and Porphyry. A. F. Wuensch (M I T–June 28.) 1600 w.

23289. Negro Miners. Editorial (T–July 1.) 550 w.

23306. The Status of the Coal Miners' Strike in Alabama (Ir Age–July 5.) 1200 w.

23313. Underground Life and Labor in the Anthracite Region. (From the N. Y. Tribune.) (Sc A S–July 7.) 3500 w.

*23318. The Manchester Ship Canal.—Its Effect on Transportation and the Possibility of Putting Pennsylvania Anthracite Into England. W. H. Booth (C E–July.) 1500 w.

*23319. Pumping with Compressed Air.—The Nottingham Colliery, Plymouth, Penna. Ill. (C E–July.) 2200 w.

23364. Gold-Mining in Carolina. D. Allen Willey (M R–July 6.) 900 w.

*23419. Sosnowice Collieries, Dombrova Coalfield, Russian Poland. Ill. (C G–June 29.) 5500 w.

*23421. The Transmission of Power by Compressed Air for Above-Ground Purposes. M. E. (C G–June 29.) 1200 w.

*23422. Sliding Scales (C G–June 29.) 4200 w.

*23423. The Colliery Fireman: His Training, Treatment, Position and Duties. George Elce (I C T–June 29.) 4000 w.

23437. A Brief Sketch of Barnato's Rise. (From the Chicago Times.) (Min R–June 21.) 1200 w.

23438. To Save Coal Waste. (From the Carbondale, Pa., Leader.) (Min R–June 21.) 800 w.

Serials.

12450. The Coal Fields of Canada. Ill. William Hamilton Merritt (C E–Began May, 1893—13 parts to date—30 cts. each).

19079. Talks on Quarrying. Edward H. Williams, Jr. (S–Began Jan.—5 parts to date—30 cts. each).

20407. Mine Surveying.—Methods Employed in the Coal Fields of Pennsylvania. Otto C. Burkhart (C E–Began March—Ended July—5 parts—30 cts. each).

20413. Mining Methods. Ill. (C E–Began March—5 parts to date—30 cts. each).

20414. Geology of Coal. Ill. (C E–Began March—5 parts to date—30 cts. each).

20415. Mining Machinery. Ill. (C E–Began March—5 parts to date—30 cts. each).

20416. Chemistry of Mining. Ill. (C E–Began March—5 parts to date—30 cts. each).

20737. British Ore Producing Districts to Compete with Spanish Minerals. Walter J. May (Inv–Began March 10—4 parts to date—30 cts. each).

22045. The Wyalong Goldfield (A M S–Began March 24—7 parts to date—30 cts. each).

22053. The Ethridge Goldfield (A M S–Began April 14—2 parts to date—30 cts. each).

22055. Commercial Mining. F. Danvers Power (A M S–Began April 14—3 parts to date—30 cts. each).

22586. The Mineral Hydrocarbons. Henry G. Hanks (M S P–Began June 2—4 parts to date—15 cts. each).

22616. Metal Mining. Albert Williams, Jr. (C E–Began June—2 parts to date—30 cts. each).

22617. A Typical Gold Mine.—Description of the Standley Consolidated Mine, Colorado. Ill. Arthur Lakes (C E–Began June—2 parts to date—30 cts. each).

22836. The Gold Mining Industry in Canada in 1893. Archibald Blue (E M J–Began June 16—2 parts to date—15 cts. each).

23207. The Origin and the Mode of the Formation of Coal. Adolphe Firket (C G–Began June 22—1 part to date—30 cts).

RAILROADING.

*22659. Early American Locomotives and Cars. Ill. (E–June.) 1500 w.

*22675. The Antofagasta (Chile) and Bolivia Railway (I & I–April 20.) 600 w.

*22679. The Upper Egypt Railway Extension. Ill. (I & I–May 4.) 800 w.

22711. Length of Steel Rails, with Editorial (R A–June 8.) 3000 w.

22712. The Miners' War Upon the Railways (R A–June 8.) 1200 w.

*22728. The Mersey Railway Engines. Ill. Clement E. Stretton (R W–June.) 700 w.

*22729. The Barmen Electric Rack Railway. Ill. (R W–June.) 1800 w.

*22731. Light Railways in Belgium. Ill. Frank B. Lea (R W–June.) 1800 w.

22748.—75 cts. The Pacific Railway Debts. Henry K. White (J P E–June.) 9500 w.

22757. Silver Memorial Vase of Department of Transportation Exhibits, World's Columbian Exposition. Ill. (R R–June 9.) 1200 w.

22759. The Reported Amendment to the Interstate Commerce Law, with Editorial (R R–June 9.) 5700 w.

22760. Couplers and Draft Appliances (R R–June 9.) 1700 w.

22802. The Stephenson Link Motion. J. Esrey Johnson, Jr. (E N–June 14.) 3300 w.

22808. Efficiency of Safety Plugs for Locomotive Boilers. Ill. (E N–June 14.) 1400 w.

22815. Concerning Locomotive Boiler Construction. James L. Spiers (R G–June 15.) 1200 w.

22816. Steel Freight Car Truck Frames, with Editorial. Ill. (R G–June 15.) 5600 w.

22817. Economy of Locomotives Compared with Stationary and Marine Engines (R G–June 15.) 1000 w.

22818. A Drawbar for Elevated Railroad Service. Ill. Design of D. L. Barnes (R G–June 15.) 700 w.

22819. Internal Friction of Locomotives (R G–June 15.) 2300 w.

*22822. French Railway Problems (R'y T–June 9.) 750 w.

22899. Are Fast Freight Lines an Evil? Editorial and Letters (R A–June 15.) 2200 w.

22900. The Railways and Coal Mine Strikers (R A–June 15.) 700 w.

22901. The Year's Progress in Car Construction. Ill. (R A–June 15.) 1600 w.

22902. M. C. B. Association Report on Steel Tired Wheels. Ill. (R A–June 15.) 250 w.

*22914. Rack Railways (R P L–June 1.) 1200 w.

*22915. Great Train Robberies (R P L–June 1.) 2100 w.

*22916. The Liverpool and Manchester Railway Sixty-five Years Ago.—Letter from George Stephenson, Oct. 25, 1829. (R P L–June 1.) 1300 w.

†22920. The Nilgiri Railway. Ill. (I E–May 12.) 1200 w.

*22928. The Uganda Railway (Tr–June 8.) 2100 w.

22988. Impact Tests of M. C. B. Couplers (E N–June 21.) 1300 w.

22998. Track Circuit Connection for Lock-and-Block Signaling. Ill. (R G–June 22.) 1200 w.

22999. Irregular Wear of Locomotive Driving Wheels. Ill. (R G–June 22.) 2000 w.

†23025. Track. L. F. Loree (B U W—No. 1.) 9500 w.

23073. Car Mileage and Accounts. Editorial. (R R–June 23.) 1000 w.

23074. The Requirements of Railroad Management (R R–June 23.) 800 w.

23084. The Heilmann Electric Locomotive.—Translation of an Article in L'Independant Remois (Eng–June 23.) 1200 w.

*23088. Light Railways for Agriculture (I C T–June 15.) 1100 w.

*23091. The London and South-Western Railway and Its Services (E–June 15.) 1800 w.

23103. High Freight Rates (A S–June 23.) 1300 w.

23105. Report on Wheel and Flange Gauges. Ill. (R A–June 22.) 5000 w.

23135. The St. Alban Landslide, near Quebec. Ill. (R G–June 29.) 1000 w.

23136. The Leslie Locomotive Fire Kindler (R G–June 29.) 1300 w.

23137. Settlement of Demurrage on the "24-Hour Average" Basis. A. M. Simmons (R G–June 29.) 1500 w.

23174. Brakeshoe Tests by the Master Car Builders' Association. Ill. (E N–June 28.) 1500 w.

23178. Steel-Tired Wheels in Use in the United States. Ill. (E N–June 28.) 300 w.

23180. Results of Tie Preservation by the Wellhouse Process (E N–June 28.) 500 w.

23257. War Upon the Public.—An Extensive Railway Strike Inaugurated under Pretense of Boycotting Pullman Cars (R A–June 29.) 2800 w.

23258. The Freight Bureau's Victory over Southern Railways (R A–June 29.) 1200 w.

23259. Year's Progress in Locomotive Construction. Ill. (R A–June 29.) 2200 w.

*23263. A Trip in Old Mexico. Ill. J. A. H. (L E–July.) 2000 w.

*23264. Block Signaling. Editorial. (L E–July.) 2000 w.

*23266. Science of Railroading. J. E. Phelan (L E–July.) 1500 w.

*23267. Uniform Air Pressure.—Letter from George Holmes (L E–July.) 1800 w.

23285. Nebraska's Apparent Hostility to Railroads. J. W. Johnson (From the Independent.) (R R–June 30.) 2300 w.

*23299. Report of Committee on Lubrication of Cars (N C B–July.) 4300 w.

*23300. Report of Committee on Ventilation of Passenger Equipment (N C B–July.) 3800 w.

23352. The International Railway Congress (E N–July 5.) 2600 w.

23355. Compressed Air and Hydraulic Machinery in Car Shops and Yards. Ill. (E N–July 5.) 1800 w.

23357. Forty Years' Decrease in Freight Rates. L. S. and M. S. Ry. (E N–July 5.) 400 w.

23367. Renewal of Drawbridge on the Jacksonville, Tampa and Key West Railroad. Ill. (R G–July 6.) 1500 w.

23368. English Experience of Train Lighting by Electricity. C. H. G. (R G–July 6.) 1800 w.

23369. Freight Car Statistics. (Extract.) W. W. Wheatly (R G–July 6.) 1200 w.

23371. Cost of Maintenance of Locomotives. Editorial (R G–July 6.) 1700 w.

*23424. Railway Development and Prospects. (I C T–June 29.) 1100 w.

23476. The Financial Folly of the Strike. Editorial (R A–July 6.) 600 w.

23477. The Great Strike—War of the "American Railway Union" on the Railways and the Entire Public (R A–July 6.) 5500 w.

23479. The Railroad Strike. Editorial (B D–July 7.) 1000 w.

Serials.

15496. Railroad Copper-smithing. Ill. John Fuller, Sr. (L E–Began Sept. 1893—9 parts to date—30 cts. each).

17826. The Evolution of the Air-Brake. Ill. Paul Synnestvedt (R E M–Began Dec.—7 parts to date—15 cts. each).

22399. Present Practice in Specified Loadings for Railroad Bridges. Ward Baldwin (R G–Began June 1—3 parts to date—15 cts. each).

22863. American Railway Car Couplers. Ill. (E–Began June 8—Ended June 29—4 parts—30 cts. each).

22869. The Enlargement of Liverpool Street Station, Great Eastern Railway. Ill. (Eng L–Began June 8—3 parts to date—30 cts. each).

22893. The Progressive Centralization of Power in the Federal Government. (From the Independent.) Aldace F. Walker, with Editorial. (R R–Began June 16—Ended June 23—2 parts—15 cts. each).

22918. The Early History of the Great Northern Railway. G. A. Sekon (R P L–Began June 1—1 part to date—30 cts).

STREET RAILWAYS.

22782. Budapest Electric Conduit Railway (E W–June 16.) 1000 w.

22788. Gas Motors for Street Railways—From report of William E. McKay (Sc A S–June 16.) 2500 w.

22814. Kinks in the Cable (M S P–June 9.) 900 w.

*22850. Tramway Traction in Newcastle-upon-Tyne (E E L–June 8.) 4500 w.

*22853. Cycle Railways: A New Departure in Cycling. W. Cave Thomas (Inv–June 9.) 900 w.

*22856. Motor Inspection. William M. Ramsey (S R R–June 15.) 800 w.

*22858. The Electric Railway as a Philanthropist (S R R–June 15.) 1000 w.

*22859. Time Tables and Train Schedules (S R R–June 15.) 700 w.

*22860. Operating Expense of the Intramural Electric Elevated Railway (S R R–June 15.) 1200 w.

*22861. A Cable Railway on the Ice. Ill. (S R R–June 15.) 750 w.

22903. Annual Report of the Budapest Electric Railway System (S R G–June 16.) 700 w.

22905. Steam and Electric Railways. Thomas L. Greene (S R G–June 16.) 1900 w.

*22917. How to Provide for the Increasing Suburban Traffic. G. A. Sekon (R P L–June 1.) 2000 w.

22964. Estimated Cost of Substituting Electricity for Cable on the Brooklyn Bridge (E E N Y–June 20.) 700 w.

23075. Electric Railway Motor Tests. W. Nelson Smith (S R G–June 23.) 1800 w.

23139. Electrolysis—Its Causes and Cure (M S P–June 23.) 4200 w.

*23227. Hamburg Electric Railway. Ill. (E R L–June 22.) 1400 w.

†23338. Cincinnati and Its Street Railways. Ill. C. B. F. (S R J–July.) 10500 w.

†23339. The Electric Railway of Genoa, Italy. Ill. (S. R. J–July.) 1800 w.

†23340. The Wheel and the Rail. Ill. Fred H. Fitch (S R J–July.) 3500 w.

†23341. Hot Springs, Ark. ; Memphis, Tenn. Ill. C. B. F. (S R J–July.) 5500 w.

23395. The Overhead Trolley System. O. M. Rau. (From Cassier's Magazine.) (E I–July.) 3300 w.

*23458. The Three-Wire System in Traction Work. Ill. E R L–June 29.) 700 w.

23464. Results of Electrolysis in St. Joseph, Mo. (S R G–July 7.) 1600 w.

23467. The Law of Negligence as Applied to Electric Street Car Collisions. R. D. Fisher (S R G–July 7.) 1200 w.

Serials.

18711. Electric Railway Motors ; Their Construction and Operation. Nelson W. Perry (S R G–Began Jan. 6—26 parts to date—15 cts. each).

21747. Steam Tramway Locomotives. Ill. H. Conradi (R W–Began April—3 parts to date —30 cts. each).

22085. Metropolitan Railways of New York and London (R G–Began May 18—4 parts to date—15 cts. each).

23260. Electric Railway Conduit Systems. Ill. F. Jarvis Pattin (S R G–Began June 30—2 parts to date—15 cts. each).

SANITARY ENGINEERING.

*22654. The Chicago Drainage Channel and Waterway. Ill. George P. Brown (E Mag–Aug.) 3000 w.

*22721. Sewer and Drain Ventilation. W. W. West (S R–June 2.) 2500 w.

22907. A Study of Sewerage Assessments. Ill. (E R–June 16.) 2700 w.

22959. Lessons in Practical Plumbing. Ill. Grayson (S P–June 15.) 2300 w.

23020. The Chautauqua Sewage Disposal Works. Ill. (E R–June 23.) 1300 w.

23095.—75 cts. The Removal of Pathogenic Bacteria from Drinking Water by Sand Filtration. George W. Fuller (T Q-Dec.) 3600 w.

23096.—75 cts. The Metropolitan Sewerage System. Ill. Howard A. Carson (T Q–Dec.) 5500 w.

†23146. What German Cities Do For Their Citizens—A Study of Municipal Housekeeping. Albert Shaw (C M–July.) 9500 w.

*23160. Women and Sanitary Science. M. V. Shaler (Ch–July.) 1200 w.

23184. Method of House Drainage, Disposal of Waste and Ventilation (Met. W–June 30.) 1400 w.

23273. The Quality of Water Supplies. (Abstract.) John W. Hill (E R–June 30.)1600 w.

23390. Tests of Cement Sewer Joints. Ill. (E R–July 7.) 1400 w.

*23427. The Destruction of Refuse in a Destroyer on the Blast Furnace Principle (I & I–June 29.) 1800 w.

Serials.

5358. Sewage Purification in America. Ill. (E N–Began July 14, 1892—41 parts to date—15 cts. each).

14839. Water Purification in America (E N –Began Aug. 3, 1893—13 parts to date—15 cts. each).

21473. The Difficulties, Design and Economical Working of Dust Destructors (I & I–Began April 13—3 parts to date—30 cts. each).

22758. The Chicago Drainage Canal. Ill. (R R–Began June 9—4 parts to date—15 cts. each).

22995. Mechanical Heating and Ventilation. M. C. Huyett (I A–Began June—1 part to date —45 cts).

23275. Plumbing in Manhattan Life Insurance Building. Ill. (E R–Began June 30—1 part to date—15 cts).

23393. Ventilation of the National House of Representatives (E R–Began July 7—1 part to date—15 cts).

23410. The Heating and Ventilation of Large Buildings. Alfred R. Wolff (J F I–Began July—1 part to date—45 cts).

STEAM ENGINEERING.

*22674. Pump Valves (I & I–April 20.) 2500 w.

*22677. The Glasgow and West of Scotland Smoke Abatement Association (I & I–April 27.) 1500 w.

†22827. Errors of Measurements of Power by the Steam Engine Indicator. D. S. Jacobus (S In–April.) 3500 w.

22846. Boiler Inspection in New York City. W. B. Ruggles (S V–June 15.) 1600 w.

*22885. The Revival of the "Single" Engine. W. B. Paley (M W–June 8.) 1100 w.

22891. Corrosion in Steam Drums. Ill. (B J C–June 16.) 1500 w.

*22943. Early Steam Road Locomotives. Editorial (P Eng–June 8.) 2300 w.

*22946. The Grafton High-Speed Engine. Ill. Edward W. Anderson (P Eng–June 8.) 5000 w.

22966. Proper Connection of Steam Boilers and Engines (Abstract of Discussion presented) by Theodore F. Scheffler.) (Ir Age–June 21.) 2100 w.

22997. Boiler Pumps. George Smail (S E–May.) 2000 w.

23022. Hot-Water Heating Apparatus in a Danbury, Conn., Church. Ill. (E R–June 23.) 1200 w.

*23070. The Indicator Card of the Oil Engine. Ill. J. F. Conradi (Eng L–June 15.) 1200 w.

23122. Mechanical Draft. Editorial (Ir Age–June 28.) 1200 w.

23183. Types of Heating Boilers in the United States. Arthur C. Walworth (Met W–June 30) 4500 w.

23187. Smoke Nuisance in Boston.—What

Is Being Done to Abate It (B J C–June 30.) 2800 w.

*23192. The External Corrosion of Steam Boilers. Ill. (M W–June 22.) 1600 w.

*23203. Liquid Fuel in the Future. R. Nelson Boyd (C G–June 22.) 3200 w.

23269. Moral Responsibility of Accidents in Steam Plants. Editorial (M G–June 30.) 1000 w.

23270. Heat Units and Specifications for Pumping Engines. Albert F. Hall (M G–June 30.) 3000 w.

*23401. Compression in Steam Cylinders. Editorial (Eng L–June 29.) 1400 w.

†23412. Smoke Preventing Appliances. W. F. Sicard (J F I–July.) 3500 w.

Serials.

17823. Designing Corliss Gears. Ill. James Dunlop (P Eng–Began Nov. 24, 1893—9 parts to date—30 cts. each).

18986. Boiler Calculations. James F. Hobart (S M–Began Jan. 15—8 parts to date—15 cts. each).

19709. The Indicator and Its Diagrams. Ill. Charles Day (P Eng–Began Feb. 2—13 parts to date—30 cts. each).

20182. The Elements of Boiler-Making. Ill. C. E. Fourness (L E–Began March—5 parts to date—30 cts. each).

22874. Six German Steam Boiler Experiments with the Same Coal (Ruhr.) Ill. Bryan Donkin (Eng L–Began June 8—Ended June 15—2 parts—30 cts. each).

23251. National Boiler Insurance Company. Ill. Extract from Annual Report of Edward G. Hiller (P Eng–Began June 22—Ended June 29—2 parts—30 cts. each).

TELEPHONY AND TELEGRAPHY.

22779. The Invention of the Telegraph.—Letters from Stephen Vail and Edward L. Morse (E W–June 16.) 1100 w.

22781. The Kineto Phonograph. Ill. (E W–June 16.) 1200 w.

22789. Telephone Rates in Europe (Sc A S–June 16.) 500 w.

22980. A Method of Measuring Telephonic Currents and Electromotive Forces. Ill. Harris J. Ryan (E W–June 23.) 800 w.

22986. Growth of the Telephone Business (M S P–June 16.) 850 w.

22987. Speed of Ocean Telegraphy (M S P–June 16.) 1800 w.

†23011. Underground Telegraph Cables in West Africa (I R W–June 15.) 1000 w.

23013. Machine Currents and Railroad Telegraph Lines. J. W. Lattig (E A–June 23.) 800 w.

23014. The Telephone and the Railroad. Charles Selden (E A–June 23.) 1000 w.

23140. Batteries for Use with Telephones (M S P–June 23.) 900 w.

23308. The Load Line in Telephone Exchanges. Ill. A. V. Abbott, Jr. (E N Y–July 4.) 4000 w.

23314. How to Make Telephones and Telephone Calls. Ill. (Sc A S–July 7.) 2600 w.

23358. Invention of the Telegraph. Letter from Stephen Vail (E W–July 7.) 1200 w.

23374. Telephone Service on French Railroads. (Abstract.) G. Dumont (W E–July 7.) 800 w.

*23441. A Contribution to the Theory of Telephony. A. E. Kennelly (El–June 29.) 1800 w.

Serials.

23307. The Development of the Electric Telegraph. Stephen Vail (E N Y–Began July 4—1 part to date—15 cts).

MISCELLANEOUS.

22106. Mr. Balfour on Bimetallism. (Abstract.) (E M J–May 19.) 1800 w.

*22111. Records of Engineering Experience. Editorial (E–May 11.) 3500 w.

*22112. The Antwerp Exhibition. Editorial (E–May 11.) 3800 w.

†22129. Nicaragua and the Mosquito Coast. Ill. Robert N. Keely (P S M–June) 4000 w.

†22130. The Cincinnati Ice Dam. G. Frederick Wright (P S M–June.) 5500 w.

†22136. The Rubber Trade as Conducted in Pará. M. F. Sesselberg (I R W–May 15.) 4000 w.

*22143. Notes on Glass. Emma E. Everist (I C B–May 11.) 1800 w.

*22173. The Sources and Applications of Borax. E. L. Fleming (C T J–May 19.) 2000 w.

†22189. Topical Discussions and Interchange of Data. Ill. (A S M E–June.) 3500 w.

*22250. The University of Michigan—Ann Arbor (E–May 18.) 2200 w.

*22256. Farmers, Fallacies and Furrows. J. Sterling Morton (F–June.) 3700 w.

*22258. The Renewed Agitation for Silver Coinage: I. Need of an International Agreement. Franklin H. Head. II. The Folly of Further Agitation. Joseph C. Hendrix (F–June.) 9000 w.

*22273. Report of the Royal Commission for the Chicago Exhibition (J S A–May 18.) 30000 w.

22301. The Education and Production of Efficient Workmen. Henry Cribben (A Ar–May 26.) 3800 w.

22382. The Panama Scandal. Ill. Maurice Barrès (Cos–June.) 4000 w.

†22384. On a Mission for Kossuth. Ill. W. J. Stillman (C M–June.) 5800 w.

†22386. The Single Tax in Actual Application. Hamlin Garland (A–June.) 2500 w.

*22417. Engineers of To-Day—and Yesterday. James Henry Greathead. Ill. (E Rev–May 21.) 2000 w.

22432. The Indian Silver Experiment (E M J–June 2.) 1000 w.

*22524. Practical Training Schools. Editorial (I & I–May 18.) 1200 w.

†22531. The Geological Relations of the

Southern Appalachian Bauxite-Deposits. C. Willard Hayes (Tr A M E-June.) 3600 w.

†22537. The Bauxites: A Study of a New Mineralogical Family. Francis Laur (Tr A M E-June.) 3000 w.

†22539. The Torsional Theory of Joints. George F. Becker (Tr A M E-June.) 3000 w.

*22582. The Earthenware Industry in England.—Extract from Report of Wendell C. Warner (I S F-June.) 1600 w.

22583. American Sculptors. J. Q. A. Ward and His Work. Ill. (Ml N-June.) 1400 w.

*22590. Light and Heat Station of the University of Pennsylvania. Samuel B. Locke (E M-June.) 1800 w.

22612. The Excavations at Argos. Edward Robinson in Boston Evening Post (A & B-June 9) 1800 w.

22627. What are Atoms? Payton Spence (E A-June 9) 1500 w.

*22650. Our Enormous Annual Loss by Fire. Edward Atkinson (E Mag-Aug.) 3000 w.

*22660. The Supremacy of Britain's Trade. Editorial (E-June 1.) 2500 w.

†22662. A Reconnaissance of the Abandoned Shore Lines of the South Coast of Lake Superior. Ill. F. B. Taylor (A G-June.) 7500 w.

†22663. The Kames of the Oriskany Valley. T. W. Harris (A G-June.) 2500 w.

†22664. Lake Ronkonkoma and Other Glacial Features of Long Island. John Bryson (A G-June.) 900 w.

†22665. The Origin of Drumlins. Ralph S. Tarr (A G-June.) 5200 w.

†22705. Note on Some Appendages of the Trilobites. Ill. Charles D. Wolcott (G M-June.) 2500 w.

†22706. The Basic Eruptive Rocks of Grau (Norway) and Their Interpretation. A Criticism. H. J. Johnston-Lavis (G M-June.) 1200 w.

†22707. The Most Recent Changes of Level and Their Teaching.—The Raised Beaches. Henry H. Howorth (G M-June.) 3000 w.

†22741. Kidd's "Social Evolution."—Review by Lord Farrar (C R-June.) 5500 w.

†22742. Market Gambling. W. E. Bear (C R-June.) 7000 w.

†22743. The Race Problem in America. Charles F. Aked (C R-June.) 4800 w.

†22744. Bimetallists at the Mansion House. M. G. Mulhall (C R-June.) 2000 w.

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22772. Peter Cooper. Ill. (B & W-June.) 800 w.

†22775. Checks on Democracy in America. George Washburn Smalley (N C-June.) 7800 w.

†22776. Some Great Churches of France. II. Vézelay. Walter Pater (N C-June.) 3600 w.

†22800. Local Taxation—Its Amount and Burden. W. M. J. Williams (F R-June.) 8800 w.

†22823. The Bimetallist Agitation (B M-June.) 3000 w.

†22824. The New Taxes and the Graduation Principle. W. R. Lawson (B M-June.) 4400 w.

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†22829. The Determination of the Calorific Power of Coals by Means of a Mahler Calorimeter. Ill. A. R. Leeds (S In-April.) 3000 w.

*22872. China and Her Progress. Editorial (Eng L-June 8.) 1700 w.

22909. Granite Beds Repaired with Type-Metal. Ill. (E R-June 16.) 800 w.

*22942. Power Distribution by Electricity, Water and Gas. Ed. C. de Segundo (G W-June 9.) 4600 w.

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22992. The California Midwinter Exhibition. Ill. (Sc A-June 23.) 1200 w.

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†23006. A Visit to the Amazon Rubber Country. Ill. Hermann Reimers (I R W-June 16.) 1800 w.

†23007. Hand-Made vs. Machine Made Hose (I R W-June 15.) 1100 w.

†23008. Do the Amazonian Rubber-Trees Grow on Uplands? Courtenay De Kalb (I R W-June 15.) 600 w.

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23019. The American Propaganda at the Antwerp Fair (A & B-June 23.) 1800 w.

*23029. The Industries and Prospective Sources of Wealth in New South Wales. J. Inglis, with Discussion (J S A-June 15.) 8500 w.

*23032. Dr. Armstrong on the Publication of Scientific Literature (N-June 14.) 5000 w.

*23043. A Cycle Ride in Northern France. —The Festival of Ste Jeanne d'Arc at Orleans. Ill. (R of R-June 15.) 5000 w.

*23062. Power Distribution by Electricity, Water and Gas.—Discussion of paper by Ed. de Segundo (G W-June 16.) 2200 w.

*23064. Antonio Canova (A L-June 15.) 2500 w.

23100. The Art of Taking Casts. S. Bolland (F D-June 10.) 1800 w.

†23106. The Postal Service at New York Charles W. Dayton (N A R–July.) 3800 w.

*23117. The Kind of Money that Would Rule the World. M. D. Harter (F–July.) 2700 w.

*23189. Canadian Tariff Changes.—Taking Effect March 27, 1894 (B T J–June.) 6000 w.

*23190. Tariff Changes and Customs Regulations.—Russia, Sweden and Norway, Germany and Spain, France, Portugal, Italy, Roumania, United States, Mexico, Brazil, etc. (B T J–June.) 4800 w.

†23195. New and Little-Known Invertebrata from the Neocomian of Kansas. Ill. F. W. Cragin (A G–July.) 3500 w.

†23196. Causes and Conditions of Glaciation. Warren Upham (A G–July.) 2500 w.

†23197. The Present Condition of the Earth's Interior as Viewed from the Standpoint of the Nebular Hypothesis. W. H. Seamon (A G–July.) 1600 w.

†23198. Notes on Some Localities of Mesozoic and Paleozoic in Shasta County, California. Harold W. Fairbanks (A G–July.) 2000 w.

†23199. On a Recent Diamond Find in Wisconsin and on the Probable Source of This and Other Wisconsin Diamonds. W. H. Hobbs (A G–July.) 1000 w.

†23200. The Early Stages of Bactrites. Ill. John M. Clarke (A G–July.) 1800 w.

*23216. Engineers of To-day—and Yesterday. E. Windsor Richards. Ill. (E Rev–June.) 2000 w.

*23217. Public Works in the Australasian Colonies. R. Price-Williams (E Rev–June.) 1800 w.

*23223. The First Monopoly Patent (E–June 22.) 1600 w.

*23233. The Growth of Wealth in France and England (I C T–June 22.) 1300 w.

*23234. The Present and the Future of American Industry. Editorial (I C T–June 22.) 1350 w.

*23249. Decorative Art and Elementary Education. Selwyn Image, with Discussion (J S A–June 22.) 8400 w.

23262. The Doctrine of Bimetallism. Francis A. Walker (B I S–June 30.) 1350 w.

23288. I. Cotton Seed and Its Products. Ill, George F. Payne. II. The Various Stages of Reduction. Ill. III. Industrial Applications of Cotton Seed Oil. Robert Grimshaw (T–July 1.) 18500 w.

†23291. On the Occurrence of a Large Area of Nepheline Syenite in the Township of Dungannon, Ontario. Frank D. Adams (A J S–July.) 2800 w.

†23292. Tertiary Changes in the Drainage of Southwestern Virginia. Marius R. Campbell (A J S–July.) 3000 w.

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†23295. On Gabbros in the Southwestern Adirondack Region. C. H. Smyth, Jr. (A J S–July.) 4000 w.

†23296. Footprints of Vertebrates in the Coal Measures of Kansas. Ill. O. C. Marsh (A J S–July.) 1200 w.

†23297. The Typical Ornithopoda of the American Jurassic. Ill. O. C. Marsh (A J S–July.) 2000 w.

†23298. Eastern Division of the Miohippus Beds, with Notes on Some of the Characteristic Fossils. Ill. O. C. Marsh (A J S–July.) 1500 w.

23309. Steam and Electric Cable-Ways for Logging and Canal Boat Towing. Ill. Richard Lamb (E N Y–July 4.) 2600 w.

23354. The Prospects for Young Engineers—A Symposium, with Editorial (E N–July 5.) 9500 w.

†23362. On Money and Bimetallism. G. A. Russell (A P R–May 15.) 1700 w.

†23363. New South Wales Land Law. E. L. Du Faur (A P R–May 15.) 1600 w.

23365. Edward Atkinson Discusses Gold and Silver (M R–July 6.) 2700 w.

†23379. Monometallism and Protection. C. S. Thomas (A–July.) 4800 w.

†23380. India Silver, Wheat and Cotton. Samuel Leavitt (A–July.) 3500 w.

†23402. Wholesale Prices. A. E. (B M–July.) 1500 w.

†23403. The Bimetallic Agitation. J. P. Heseltine (B M–July.) 3800 w.

Serials.

18930. Carnot and Modern Heat. Oliver Lodge (Eng L–Began Jan. 5—13 parts to date—30 cts. each).

19052. Notes on the Manufacture of Ropes. Ill. W. C. Popplewell (P Eng–Began Jan. 12—6 parts to date—30 cts. each).

21763. Engineering Practice and Education. Gaetano Lanza (J F I–Began May—3 parts to date—45 cts. each).

22446. The Covered Markets of Europe. Marc Aurelio Boldi (E–Began May 25—Ended June 1—2 parts—30 cts. each).

22657. The Dry Method of Making Portland Cement. Chr. Engelhart (E–Began June 1—Ended June 22—3 parts—30 cts. each).

22687. On the Development of the Coach. Ill. Henry Stooke (I C B–Began June 1—1 part to date—30 cts).

22708. The Corrugation of the Earth's Surface and Volcanic Phenomena. Arthur Vaughan (G M–Began June—1 part to date—30 cts).

22848. Physical Units. Magnus Maclean (E E L–Began June 8—3 parts to date—30 cts. each).

23406. Notes on Russian Geology—The Black Earth. W. F. Hume (G M–Began July—1 part to date—45 cts).

THE·TECHNICAL·INDEX

A CATALOGUE OF LEADING ARTICLES PUBLISHED CURRENTLY IN THE TECHNICAL JOURNALS OF THE UNITED STATES AND GREAT BRITAIN.

THIS index has been very properly described as "the greatest step that has been taken in recent years towards systematizing work" for the engineer, the architect, the electrician, the railway manager, and the business man. The list of publications regularly indexed will show that it covers a world-wide range of the best technical literature, and all the articles are so conveniently classified under general headings, that within a few minutes, once a month, an active man can learn of everything of any importance that has been published during the month in relation to the subjects in which he is interested. In short, it is to the practical man just what Poole's celebrated index to periodicals has long been to the literary worker, but with this essential improvement—namely: that in addition to indicating *just when and where* leading articles have been published, *we undertake to supply copies of the articles themselves.* The unparalleled convenience and economy of this double service can readily be appreciated.

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[In the body of the index only the initials of the journals quoted are given, and these can be readily identified by the following list of periodicals. Other abbreviations are: Ill=Illustrated. w=words.]

THE AMERICAN PRESS.

A	Arena. *m.* $5. Boston.
AA	American Architect. *w.* $6. Boston.
Aer	Aeronautics. *m.* $1. N. Y.
An A A	Annals of Am. Academy of Political and Social Science. *b-m.* $6. Philadelphia.
A An	American Analyst. *f.* $1. New York.
A Ar	American Artisan. *w.* $2. Chicago.
A & B	Architecture and Building. *w.* $6. N. Y.
A B D	Architect, Builder and Decorator. *m.* $2. Minneapolis.
A C J	Am. Chem. Journal. *b-m.* $4. Baltimore.
A E	Architectural Era. *m.* $3. N. Y.
A E R J	Am. Eng. and Railroad Journal. *m.* $3. N.Y.
A G	Am. Geologist. *m.* $3.50. Minneapolis.
A G L J	Am. Gas Light Journal. *w.* $3. New York.
A H	Annals of Hygiene. *m.* $2. Phila.
A J P	Am. Jour. of Politics. *m.* $3. New York.
A J Phar.	Am. Journal of Pharmacy. *m.* $3. Phila.
A J R A	Jour. R'y. Appliances. *m.* $2. New York.
A J S	Am. Jour. of Science. *m.* $6. New Haven.
A M	American Machinist. *w.* $3. New York.
Am A	Amer. Agriculturist. *m.* $1. N. Y.
A M & I W.	Am. Man. and Iron World. $4. Pittsburg.
Am G	Amer. Gardening. *m.* $1. N. Y.
Am S	American Shipbuilder. *w.* $2. New York.
A & N J	Army and Navy Journal. *w.* $6. New York.
A & N R	Army and Navy Register. *w.* $3. Wash'ton.
A R	Architectural Record. *q.* $1. New York.
A Rev	Architectural Review. *s-q.* $5. Boston.
A S	Age of Steel. *w.* $3. St. Louis.
A S M E.	Am. Soc. of Mec. Eng. *m.* New York.
B B	Brick Builder. *m.* $2.50. Boston.
B C	Boston Commonwealth. *w.* $2.50. Boston.
B D	The Black Diamond. *w.* $3. Chicago.
B & D	Builder and Decorator. *m.* $2. Minneapolis
B G S	Bul. Am. Geog. Soc. *q.* $5. New York.
B I S	Bul. Am. Iron and St. Asso. *w.* $4. Phila.
B J C	Boston Jour. of Commerce. *w.* $3. Boston.
B U W	Bul. of the Univ. of Wisconsin.
B & W	Builder and Woodworker. *m.* $1. N. Y.
C	Compass. *m.* $1. New York.
C A	Calif. Architect. *m.* $3. San Francisco.
Can A	Canadian Architect. *m.* $2. Toronto.
C & B	Carpentry and Building. *m.* $1. New York.
C E	Colliery Engineer. *m.* $2. Scranton, Pa.
C E N	Canadian Elec. News. *m.* $1. Toronto.
C Eng	Canadian Engineer. *m.* $1. Montreal.
Ch	Chautauquan. *m.* $2. Meadville, Pa.
C M	Century Magazine. *m.* $4. New York.
C M R.	Canadian Mining Rec. *m.* $1.50. Ottawa.
Cos	Cosmopolitan. *m.* $1.50. New York.
D E	Domestic Engineering. *m.* $2. Chicago.
E A	Electrical Age. *w.* $3. New York.
E E	Electrical Engineering. *m.* $1. Chicago.
E E N Y	Electrical Engineer. *w.* $3. New York.
E I	Electrical Industries. *m.* $1. Chicago.
Elek	Elektron. *m.* $3. Boston
E M	Engineering Mechanics. *m.* $2. Phila.
E Mag	Engineering Magazine. *m.* $3. New York.
E M J	Eng. and Mining Journal. *w.* $5. N.Y.
E N	Engineering News. *w.* $5. New York.
Eng	Engineer. *s-m.* $2.50. New York.

E N Y....Electricity. *w.* $2.50. New York.
E R......Engineering Record. *w.* $5. New York.
E & R.. .Elec and Railroading. *m.* $1. Boston.
E R N Y..Electrical Review. *w.* $3. New York.
E S W P...Proc. Eng. So. of W. Pa. *m.* $7. Pittsburg.
E W.......Electrical World. *w.* $3. New York.
F.........Forum. *m.* $3. New York.
F D......The Foundry. *m.* $1. Detroit.
F W......Fire and Water. *w.* $3. New York.
G & F....Garden and Forest. *w.* $4. New York.
G G M...Goldthwaite's Geog. Mag. *m.* $2. N. Y.
G R......Good Roads. *m.* $1. New York.
I A......Inland Architect. *m.* $5. Chicago.
I Age....Inventive Age. *s-m.* $1. Washington.
Ir Age..Iron Age. *w.* $4.50. New York.
I I G.....Iron Ind. Gazette. *m.* $1.50. Buffalo.
I R W...India Rubber World. *m.* $3. New York.
I S F.....Industry. *m.* $2. San Francisco.
I T R....Iron Trade Review. *w.* $3. Cleveland.
I W .....Indus. World. *w.* $3. Chicago
J A......Journal of Architecture. *m.* $2. Phila.
J A C S..Jour. Am. Chem. So. *m.* $5. Easton.
J A E S..Jour. Assoc. Eng. Soc. *m.* $3. Chicago.
J A N E..Jour. Am. Soc. Naval Engineers. *qr.* $5. Washington.
J F I.....Jour. Franklin Institute. *m* $5. Phila.
J M S I..Jour. Milit. Service In. *b-m.* $4. NewYork.
J N E W.Jour. N. E. Waterw. As. *q.* $2. New London.
J P E.....Jour. Polit. Economy. *q.* $3. Chicago.
J U S A..Jour. U. S. Artillery. *q.* $2.50. Ft. Monroe.
L E......Locomotive Engineering. *m.* $2. N. Y.
L. H. P..Light, Heat and Power. *m.* $3. Phila.
L Mag...Lippincott's Magazine. *m.* $3. Phila.
M & B...Manufacturer and Builder. *m.* $1.50. N. Y.
M & El...Mech. and Elec. *w.* $2. St. Louis.
Met W...Metal Worker. *w.* $2. N. Y.
M G......Manufacturer's Gazette. *w.* $3. Boston.
Min......Minerals. *m.* $1. N Y.
Mill......Milling. *m.* $2. Chicago.
M N.....Mech. News. *s-m.* $1.50. N. Y.
Min. R...The Mining Review. *w.* $2. Denver.
M I T....Mining Industry. *w.* $3. Denver.
Ml N....The Monumental News. *m.* $1. Chicago.
M R......Manufacturer's Record. *w.* $4. Baltimore.
M R C...Marine Review. *w.* $2. Cleveland, O.
M Rec....The Marine Record. *w.* $2. Cleveland.
M S P....Min. and Sci. Press. *w.* $3. San Francisco.
M S R.. .Min. and Sci. Rev. *w.* $2. Denver.
N A R...North American Review. *m.* $5. N. Y.
N B......National Builder. *m.* $3. Chicago.
N C B...National Car Builder. *m.* $2. New York.
N E M...New Eng. Magazine. *m.* $3. Boston,
N P R...Nat. Popular Review. *m.* $2.50. Chicago.
N S R....The New Science Review. *qr.* $2. N. Y.
N W.....Nowest. Architect. *m.* $3. Minneapolis.
O P D R..Oil, Paint and Drug Reporter. *w.* $6. N. Y.
P....... ..Paving. *m.* $2. Indianapolis.
P A......Progressive Age. *s-m.* $3. New York.
P D... ..Painting and Dec. *m.* $1. Philadelphia.
P E .....Prac. Electricity. *f.* $2. Boston.
P E C P.Procd. Engineer's Club. *q.* $2. Phila.
Pr.......Power. *m.* $1. N. Y.
P S .....Power Steam. *m.* $1. N. Y.
P S M....Popular Science Monthly. *m.* $5. N. Y.
R A.....Railway Age. *w.* $4. Chicago.
R C J....Railroad Car Journal. *m.* $1 New York.
R E M....Railway Engineering and Mechanics. *m.* $1. Chicago.
R G .....Railroad Gazette. *w.* $4.20. N. Y.
R M.....Roller Mill. *m.* $2. Buffalo, N. Y.
R M M...Railway Master Mech. *m.* $1. Chicago.
R of R...Review of Reviews. *m.* $2.50. New York.
R R......Railway Review. *w.* $2. Chicago.
R & T...Roofer and Tinner. *m.* $1. N. Y.
Ry N.....Railway News. *m.* $2. N. Y.
S... .....Stone. *m.* $2. Chicago.
S A......Southern Architect. *m.* $2. Atlanta.
San......Sanitarian. *m.* $4. Brooklyn.
Sc........Science. *w.* $3.50. New York.
Sc A.....Scientific American. *w.* $3. New York.
Sc A S...Scientific Am. Supplement. *w.* $5. N. Y.
Sc M....Scribner's Magazine. *m.* $3. New York.
S E .....Stationary Engineer. *w.* $2. Chicago.
Sc Q.....Scientific Quarterly. *q.* $2. Golden, Cal
Sea......Seaboard. *w.* $2. New York.
S Ec......Social Economist. *m.* $2. New York.
S In......Stevens' Indicator. *qr.* $1.50. Hoboken.
S J E....Sibley Jour. of Eng. *m.* $2. Ithaca, N. Y
S M.....ScientificMachinist. *s-m.* $1.50. Cleveland, O.
So L.....Sou. Lumberman. *s-m.* $2. Nashville.
S M Q....School of Mines Quarterly. $2. N. Y.
S R E N..St. R'y. Elec. News. *m.* $2. Minneapolis.
S P......Sanitary Plumber. *s-m.* $2. New York.
S R G....Street Railway Gazette. *w.* $3. Chicago.
S R J....Street Railway Journal. *m.* $4. New York.
S R N....Street Railway News. *w.* $3. N. Y.
S R R.. .Street Railway Review. *m.* $2. Chicago.
S S......Southern States. *m.* $1.50. Baltimore.
S V......Safety Valve. *m.* $1. New York.
T........Tradesman. *s-m.* $2. Chattanooga, Tenn.
T A I E E.Trans. Am. Ins. Elec. Eng. *m.* $5. N. Y.
T C E....Trans. Am. Soc. Civil Eng. *m.* $10. N. Y.
T Q......Technology Quarterly. $3. Boston.
Tr A M E.Trans. Am. Ins. of Mining Eng. N. Y.
T W A .Trans. of the Wis. Acad. Madison.
W E......Western Electrician. *w.* $3. Chicago.
W F E E.World's Fair Elec. Eng. *m.* $3 Chicago.
W G R...Water and Gas Rev. *m.* $1. N. Y.

THE FOREIGN PRESS.

A L ....The Architect. *w.* 26*s.* London.
A M S.. Aust. Mining Standard. *w.* 30*s.* Sydney.
A P R...Aus. Pastoralists' Rev. *m.* 20*s.* Sydney.
B....... The Builder. *w.* 26*s.* London.
B A.... .The British Architect. *w.* 23*s.* 8*d.* London.
B M ....Banker's Mag. *m.* 18*s.* London,
B T J ...Board of Trade Journal. *m.* 6s. London.
C G.. ..Colliery Guardian. *w.* 27*s.* 6*d.* London.
C R......Contemporary Review. *m.* $4.50. London.
C T J....Chem. Trade Jour. *w.* 12*s.* 6*d.* Manchester.
D........Discovery. *w.* 8*s.* 8*d.* London.
E.........Engineering. *w.* 36*s.* London.
E E L....Electrical Engineer. *w.* 19*s.* 6*d.* London.
E G......Engineers' Gazette. *m.* 8*s.* London.
E L.......Electricity. *w.* 7*s.* 6*d.* London.
El.. .....Electrician. *w.* 24*s.* London.
EngL... Engineer. *w.* 36*s.* London.
E P......Electrical Plant. *m.* 6*s.* London.
E Rev....Engineering Review. *m.* 7*s.* London.
E R L.....Electrical Review. *w.* 21*s.* 8*d.* London.
F R......Fortnightly Review. *m.* $4.50. London.
F'y......Fairplay. *w.* 32*s.* 6*d.* London.
G E M...Gas Engrs' Mag. *m.* 6*s.* 6*d.* Birmingham.
G M.....The Geol. Mag. *m.* 18s. London.
G W......Gas World. *w.* 13*s.* London.
I... .....Iron. *w.* 30*s.* London.
I & I.....Industries and Iron. *w.* £1. London.
I & S.....Iron & Steel Trades' Jour. *w.* 25*s.* Lond.
I C B....Carpenter and Builder. *w.* 8*s.* 8*d.* London.
I C T......Iron and Coal Trades. *w.* 30*s.* 4*d.* London.
I E.......Indian Engineering. *w.* 18 Rs. Calcutta.
I Eng....Indian Engineer. *w.* 20 Rs. Calcutta.
Irm......The Ironmonger. *w.* 10*s.* London.
Inv .....Invention. *w.* 11*s.* London.
I S C.....The Iron, Steel and Coal Times. *w.* £1 6*s.* London.
J G L....Journal of Gas Lighting. *w.* London.
J S A....Journal of the So. of Arts. *w.* London.
K........Knowledge. *m.* 6s. London.
M........Machinery. *m.* 9*s.* London.
M E......Marine Engineer. *m.* 7*s.* 6*d.* London.
M E & E J.Man. Eng. and Ex. Jour. *m.* London.
Min W..The Mining World. *w.* 21*s.* London.
M J......The Mining Jour. *w.* £1. 8*s.* London.
M W.....Mechanical World. *w.* 8*s.* 8*d.* London.
N....... Nature. *w.* $7. London.
N C......Nineteenth Century. *m.* $4.50 London.
P Eng...Practical Engineer. *w.* 10*s.* London.
Pl D .....Plumber and Decor. *m.* 6*s.* 6*d.* London.
R N......Railway News. London.
R P L....The Railway Press. *m.* 7*s.* London.
R R L....The Railway Review. *w.* London.
R W.....Railway World. *m.* 5*s.* London.
Ry T.. ..The Railway Times. £1. 5*s.* London.
S L......Steamship. *m* Leith, Scotland.
S R......Sanitary Record. *m.* 10*s.* London.
Tr.......Transport. *w.* £1. 5*s.* London.
W R.....Westminster Review. *m.* $4.50. London.

ARCHITECTURE.

*23482. Theater-Building for American Cities. Ill. Daukmar Adler (E Mag-Sept.) 3000 w.

*23515. Stories in Stone.—The Great Duomo at Florence, Italy. Ill. Arthur Lee (S-July.) 2800 w.

*23556. Decorative Pilasters and Panels. Ill. H. Leslie Ramsey (Pl D-July.) 1300 w.

*23558. Color Treatment of Interiors (Pl D-July.) 1000 w.

*23559. Tinting Ceilings and Cornices. Frederick Parsons (Pl D-July.) 1350 w.

23566. Pneumatic Foundation Construction, American Surety Building. Ill. (E R-July 14.) 3000 w.

23586. The Remains of Aksum, Abyssinia (A & B-July 14.) 2600 w.

*23624. Augustus Welby Pugin. Ill. (A L-July 6.) 2800 w.

*23627. The Restoration of St. Michael's Church, Linlithgow (A L-July 6.) 3600 w.

*23643. Westminster Abbey (I C B-July 6.) 1700 w.

23647. Zinc and Zinc Roofing (R & T-July.) 1800 w.

*23651. Modern Architecture. Ill. Montgomery Schuyler (A R-July-Sept.) 8300 w.

*23655. Architectural Aberrations.—The Medinah Temple. Ill. (A R-July-Sept.) 1400 w.

*23656. Origin of the Acanthus Motive and Egg-and Dart Moulding. Ill. William H. Goodyear (A R-July-Sept.) 6500 w.

23697. The Use of Cork as a Building Material. S. Sampolo (Sc A S-July 21.) 1100 w.

23699. The Ancient Monuments and Palatial Architecture of Mexico and Central America (Sc A S-July 21.) 2500 w.

23723. The Rational Design of Columns. Ill. Mansfield Merriman (E N-July 19.) 4500 w.

23742. The Difference in Amount of Radiation Required in Buildings of Good and Poor Construction. E. P. Bates (E R-July 21.) 3000 w.

*23772. Christ Church Cathedral, Montreal (Can A-July.) 1200 w.

*23876. Highland Architecture. Professor Blackie (I C B-July 20.) 1300 w.

*23877. Homes Abroad (I C B-July 20.) 1300 w.

*23921. The Chimneypiece. P. Morley Horder (A L-July 20.) 1200 w.

23927. Architects and the Tenement House. Edward L. Angell (A & B-July 28.) 900 w.

23928. The Difficulties of a Young Architect. A. O. Collard (A & B-July 28.) 4300 w.

†23950. The Engineering Features of the Harrison Buildings at Tenth and Market, and Tenth and Filbert Streets. W. Copeland Furber (P E C P-April-June.) 1800 w.

23969.—75 cts. The Central Building of the World. Henry Van Brunt (A Rev-Vol. III. No. II.) 1800 w.

23987. The Brooklyn, New York, New Fire Department Headquarters. Ill. (E E N Y-Aug. 1.) 1800 w.

*24005. Municipal Requirements for the Thickness of Walls. F. E. Kidder (B B-July.) 1800 w.

*24009. A Review of Various Methods of Concrete Construction as Applied in Engineering Works. Ross F. Tucker (B B-July.) 1600 w.

*24010. Mortar Colors and Stains. R. N. Buell (B B-July.) 1100 w.

24047. Girder Rails in Building Construction. Ill. (E R-Aug. 4) 1100 w.

24057. The Proposed Commission on Public Architecture (E N-Aug. 2.) 900 w.

*24103. The Province of Our Architectural Schools (I C B-July 27.) 800 w.

24121. The Astor Memorial Doors for Trinity Church. Ill. (Ml N-Aug.) 800 w.

*24123. Glass. F. D. Sweeny (S A-Aug.) 1600 w.

*24131. Progress of the Excavations at Delphi (B-July 28.) 2600 w.

Serials.

12568. Building Construction and Superintendence. Ill. F. E. Kidder (A & B-Began May 6, 1893—30 parts to date—15 cts. each).

16576. Architects' Houses. Ill. John Beverley Robinson (A R-Began Oct.-Dec.—4 parts to date—30 cts. each).

18214. The École des Beaux-Arts. Ernest Flagg (A R-Began Jan.-March—3 parts to date—30 cts. each).

19078. Problems in Stone-Cutting. Ill. Ed. W. Hind (S-Began Jan.—6 parts to date—30 cts. each).

19713. Brick and Marble in the Middle Ages. Ill. (B B-Began Jan.—7 parts to date—30 cts. each).

19749. Lead Light and Stained Glass Glazing. Jehan Le Vitrier (Pl D-Began Feb.—Ended July—6 parts—30 cts. each).

20419. Modern Methods of House Painting. A. Ashmun Kelly (Pl D-Began March—5 parts to date—30 cts. each).

21150. Limestone as a Building Stone. T. C. Hopkins (S-Began April—3 parts to date—30 cts. each).

21288. Theatres. Ill. E. A. E. Woodrow. (A A-Began April 14—4 parts to date—15 cts. each).

21464. Henry Van Brunt—Architect, Writer and Philosopher. P. B. Wight (I A-Began April—4 parts to date—45 cts. each).

21618. Bay Windows and Oriels. Ill. F. Jerman (I C B-Began April 20—5 parts to date—30 cts. each).

21639. The Italian Renaissance. A. D. F. Hamlin (A A-Began April 28—6 parts to date—15 cts. each).

21736. The Art of Building among the Romans. Ill. Auguste Choisy. Translated by Arthur J. Dillon (B B-Began April—4 parts to date—30 cts. each).

22717. Terra-Cotta in Skeleton Construction. Ill. D. Everett Waid (B B-Began May—2 parts to date—30 cts. each).

23045. The Essential Conditions of Safety in Theatres. William Paul Gerhard (A A-Began June 23—4 parts to date—15 cts. each).

23517. The Stone-Masons of Scotland. John Mortimer (S-Began July—1 part to date—30 cts).

23592. Towers and Turrets. Ill. Anthyme Saint-Paul (A A-Began July 14—2 parts to date—15 cts. each).

23597. Across Argolis. Ill. Thomas A. Fox (A Rev-Began Vol. III. No. I—1 part to date—75 cts).

23625. "Is Gothic Architecture a Failure?" (A L-Began July 6—Ended July 20—3 parts—30 cts. each).

23626. The True Principles of Pointed or Christian Architecture. Ill. A. Welby Pugin (A L-Began July 6—4 parts to date—30 cts. each).

23652. Architecture in Spain. Ill. Charles A. Rich (A R-Began July-Sept.—1 part to date—30 cts).

24102. Architecture and Its Civic and Commercial Value. Banister Fletcher (I C B-Began July 27—1 part to date—30 cts).

24124. Architectural Competitions for Public Buildings. George F. Hammond (S A-Began Aug.—1 part to date—30 cts).

CIVIL ENGINEERING.

*23485. The Present Condition of the Panama Canal. Oscar A. F. Saabye (E Mag-Sept.) 3000 w.

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*23519. Roadways and Street Pavements. William L. Dickinson (S-July.) 2800 w.

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23567. Advice to Civil Engineering Graduates. Joseph M. Wilson (E R-July 14.) 2000 w.

23583.—$1.50. The Use of Canvas in Water-Tight Bulk Heads. Ill. M. Meigs, with Discussion (T C E-May.) 5800 w.

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†23603. The Canals of Commerce. Lewis M. Haupt (N S R-July.) 1800 w.

*23645. Testing Concrete at Glasgow (I C B-July 6.) 1100 w.

*23646. Smeaton's Experiments with Lime Mortar (I C B-July 6.) 1800 w.

*23760. Portland Cement (E-July 13.) 1200 w.

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*23901. Mineral Rock Asphalte. Mr. Blake (I C T-July 20.) 800 w.

*23902. A New Type of Truss. H. F. Coleman with Discussion (J A E S-May.) 2000 w.

*23904. The Original Construction of the Burlington Bridge in 1867-68. Ill. C. H. Hudson, with Discussion (J A E S-May.) 7200 w.

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†23948. Notes on the Improvement of Philadelphia Harbor. L. T. Schermerhorn, with Discusion (P E C P-April-June.) 5700 w.

†23995. Creosote for Sleepers (I E-June 30.) 1400 w.

24014. Smulder's Suction Dredger. Ill. (Sc A S-Aug. 4.) 800 w.

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Serials.

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22793. Road Engineering. W. H. Breithaupt (C Eng-Began June—2 parts to date—15 cts. each).

24032. Road Making in the South. W. E. Voorhes (T-Began Aug. 1—1 part to date—15 cts).

ELECTRIC LIGHTING.

23617. The Incandescent Lamp.—Its Use and Abuse (T-July 15.) 2200 w.

23648. The Westinghouse Stopper Incandescent Lamp. Ill. (E R N Y-July 18.) 1100 w.

23812. Street Lighting by Alternating Arcs. R. E. Richardson and S. G. Neiler (E E N Y-July 25.) 2000 w.

23856. Incandescent Lamps; Their Use and Abuse. A. D. Page (W E–July 28.) 2800 w.

23870. Electricity on the Sound Steamer "Priscilla." Ill. (E W–July 28.) 3000 w.

*23912. Three Municipal Electricity Supply Works.—Derby, Manchester, Burton. Ill. (E R L–July 20.) 8200 w.

23965. A Monster Flash Light Lens (Min R–July 19.) 600 w.

24058. Storage Batteries for Lighting Apartment Houses in Chicago. Ill. (W E–Aug. 4.) 1400 w.

*24095. The Decorative Use of Glow Lamps. J. A. Fleming (El–July 27.) 2200 w.

24112. Government Inspection of Electric Light in Canada (C E N–Aug.) 2500 w.

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Serials.

22131. The Incandescence Lamp. A. Bainville (E R L–Began May 11—4 parts to date—30 cts. each).

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24018. A Bolometric Study of Light Standards. Clayton H. Sharp and W. R. Turnbull (E N Y–Began Aug. 1—2 parts to date—15 cts. each).

24194. Electric Lighting in Great Britain. E. Ray Stevens (E W–Began Aug. 11—1 part to date—15 cts).

ELECTRIC MISCELLANY.

*23491. Tesla's Discoveries in Electricity. Nelson W. Perry (E Mag–Sept.) 3000 w.

23494. Physical Analysis of the Conditions on a Circuit Containing Distributed Capacity and Self-Induction when Subjected at One Point to a Simple Harmonic E. M. F. Ill. William A. Anthony (E E N Y–July 11.) 2400 w.

23505. Inductance of Lines. G. M. Warner (E W–July 14.) 600 w.

†23604. Nikola Tesla and His Works. N. Jarvis Patten (N S R–July) 2200 w.

*23631. Direct-Reading Apparatus for the Determination of the Magnetic Qualities of Iron. M. A. Koepsel (El–July 6.) 1200 w.

*23638. "A Living Price" in Electrical Engineering. Sydney F. Walker (E R L–July 6.) 1500 w.

23650. The Storage Battery of the Air. Alexander M'Adie in Harper's Magazine (E R N Y–July 18.) 600 w.

23703. Locating Faults and Crosses. Louis C. Hill (E E N Y–July 18.) 250 w.

*23767. Notes on Electrical Literature. Fred J. Prouting (I C B–July 13.) 2800 w.

*23769. Peculiarities of the Electrical Profession (E L–July 13.) 2500 w.

*23799. Note on the Possibility of Obtaining a Uni-directional Current to Earth from the Mains of an Alternating Current System. Ill. Major P. Carden (El–July 13.) 800 w.

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23801. Resonance Analysis of Alternating and Polyphase Currents. Ill. M. I. Pupin (W E–July 21.) 7500 w.

*23802. Studying Electricity. George D. Shepardson (S R E N–July) 1100 w.

23811. Gas Engines and Electric Transmission from the Coal Mines. J. C. Henderson (E E N Y–July 25.) 1100 w.

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23855. Electric Launches in Chicago Parks. Ill. (W E–July 28.) 1200 w.

23861. The Electrical Chimeano. An Ingenious Instrument. (B J C–July 28.) 800 w.

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*23907. The Electrification of Air. Lord Kelvin and Magnus Maclean (N–July 19.) 2800 w.

*23915. The "Practical" Wiring Chart. Ill. A. G. Sanders (El–July 20.) 900 w.

24017. "Was Moses an Electrician?" Reply to C. B. Warrand by Thomas D. Lockwood (E N Y–Aug. 1.) 1000 w.

24059. Corrosion of Pipes in Boston by Electrolysis (W E–Aug. 4.) 2700 w.

24060. The Relations Between Technical Schools and Electrical Industries. G. D. Shepardson (W E–Aug. 4.) 1800 w.

*24093. On the Diselectrification of Metals and Other Bodies by Light. Ill. Oliver Lodge (El–July 27.) 2800 w.

24177. The Resonance of Electrical Circuits. F. W. Dunbar (E E N Y–Aug. 8.) 4300 w.

Serials.

17546. Recollections of Werner Von Siemens (E N Y–Began Nov. 22, 1893—11 parts to date—15 cts. each).

19099. Design of Electro-Magnets for Specific Duty. Ill. E. R. Carichoff (E W–Began Jan 27—3 parts to date—15 cts. each).

22059. Practical Notes on Dynamo Calculations. Alfred E. Wiener (E W–Began May 19—13 parts to date—15 cts. each).

23439. On Impulsive Current-Rushes in Inductive Circuits. Alfred Hay (El–Began June 29—4 parts to date—30 cts. each).

24090. The Various Methods of Charging the Public for Electricity from a Central Station. Alfred H. Gibbings (E R L–Began July 27—1 part to date—30 cts).

24198. Action of a Transformer with a Condenser in Parallel with the Secondary. Frederick Bedell and Albert C. Crehore (E W–Began Aug. 11.—1 part to date—15 cts).

ELECTRIC POWER.

23532. Water Supply Power and Electric Works at Zurich, Switzerland. Ill. (E N–July 12.) 2500 w.

23704. Thwaites Electric Power Transmission Scheme from the Coal Fields to London with Editorial. Ill. (E E N Y–July 18.) 4000 w.

23808. Electric Plants Driven by Gas Engines. Ill. (S. M–July 15.) 800 w.

23834. A Twelve Mile Transmission of Power by Electricity (Abstract.) Ill. Thomas H. Leggett. (E N–July 26.) 5800 w.

23857. Cost of Producing Electrical Energy. B. J. Arnold (W E–July 28.) 2200 w.

*23916. The Application of Small-Power Electric Motors, with Editorial. Ill. (El–July 20.) 2000 w.

23977. A New Departure in Electric Railway Power Houses. Columbus. Ill. (E R N Y–Aug. 1.) 700 w.

24025. Power Station Switch Boards. F. R. Slater (Pr–Aug.) 2500 w.

24061. The Modern Dynamo. Gilbert Donaldson (W E–Aug. 4.) 800 w.

*24138. Distribution of Electrical Energy by Alternating Currents. Ill. W. Lowrie's System (E E L–July 27.) 3800 w.

24186. The Use of Electric Motors for Driving Machine Tools (E N–Aug. 9.) 1600 w.

24197. Some Facts about Polyphase Motors. Louis Bell (E W–Aug. 11.) 3700 w.

Serials.

11560. Electric Motive Power. Ill. Albion T. Snell (El–Began March 17, 1893—17 parts to date—30 cts. each).

23628. Electrically Driven Mining Drills. Ill. J. W. Chubb (P Eng–Began July 6—Ended July 20—2 parts—30 cts. each).

23866. Electro-Dynamic Machinery. Edwin J. Houston and A. E. Kennelly (E W–Began July 21—2 parts to date—15 cts. each).

23868. Amateur Motor Building. Ill. G. E. Dunton (E W–Began July 21—2 parts to date—15 cts. each).

GAS ENGINEERING.

23514. The Liquefaction and Solidification of Air and Gases. Henry Wurtz (Sc A S–July 14.) 3800 w.

*23543. Discussion on Thomas Newbigging's Paper, on "Illuminating Power and Illuminating Effect" (J G L–July 3.) 8500 w.

*23544. Discussion on George Anderson's Paper on "Differental Charges for Gas" (J G L–July 3.) 3200 w.

*23545. Discussion on Dr. Voisey's Paper on "An Improvement in the Construction of Atmospheric Burners" (J G L–July 3.) 1800 w.

*23546. Notes on Gas Manufacture at Wallasey with Special Reference to Enrichment by Cannel. H. Ashton Hill (J G L–July 3.) 3500 w.

*23547. The Application of Coal Tar for Making Gas. C. Stafford Ellery (J G L–July 3.) 2400 w.

*23548. Construction and Working of Regenerator Settings of Retorts. W. R. Chester (J G L–July 3.) 3800 w.

*23549. An Improved Tar Extractor. Ill. F. D. Marshall (J G L–July 3.) 700 w.

23594. Electric Lighting vs. Gas. Edward M. Harris (A G L J–July 16.) 1300 w.

23596. The Relations between Gas Companies and Gas Consumers. William Paul Gerhard, in Cassier's Magazine (A G L J–July 16.) 4200 w.

*21633. Gaseous Fuel in the Retort House. T. S. Cleminshaw (G W–July 7.) 3000 w.

*23634. Special Applications of Gas. Ill. Norton H. Humphrys (G W–July 7.) 2200 w.

*23635. Gaseous Fuel. T. Travers (G W–July 7.) 3700 w.

*23636. Discussion of Paper by Frederick G. Dexter, on "Steam Applied as an Aid to the Revivification of Oxide of Iron in Situ" (G W–July 7.) 1600 w.

*23709. Discussion of Mr. Stelfox's Paper on "A First Season's Experience of Carburetted Water Gas" (J G L–July 10.) 4800 w.

*23710. Discussion of Mr. H. Ashton Hill's Paper on "Gas Manufacture at Wallasey, with Special Reference to Enrichment by Cannel" (J G L–July 10.) 2800 w.

*23711. Discussion of Mr. C. Stafford Ellery's Paper on "The Application of Coal Tar for Making Gas" (J G L–July 10.) 3200 w.

*23712. The Gas and Electricity Supply of Blackpool. William Chew (J G L–July 10.) 5500 w.

*23751. The Lighting of the Tower Bridge. Ill. (I & I–July 13.) 700 w.

*23788. My Experiences with Some Leaky Gasholder Tanks. Ill. J. Chadwick (G W–July 14.) 3200 w.

*23859. Discussion on the Papers by Messrs, Chester, Travers and Cleminshaw, on Regenerative Retort Settings and Gaseous Fuel (J G L–July 17.) 10000 w.

*23860. Discussion on Mr. W. Chew's Paper on "Gas and Electric Lighting at Blackpool" (J G L–July 17.) 3800 w.

*24001. Discussion of Mr. Chadwick's Paper on "My Experiences with Some Leaky Gasholder Tanks" (J G L–July 24.) 1600 w.

*24002. Young's Improvements in the Production of Illuminating Gas. Ill. (J G L–July 24.) 4300 w.

24003. Enrichment of Coal Gas. Alexander C. Humphreys (P A–Aug. 1.) 3000 w.

24004. Welsbach Incandescent Burners. E. G. Love (P A–Aug. 1.) 1400 w.

24024. A Three Hundred Horse-Power Gas Engine Plant. Ill. (Pr–Aug.) 1000 w.

*24101. A Natural Gas Forge (I C B–July 27.) 900 w.

Serials.

13534. The Gas Engine. Ill. (M W–Began June 2, 1893—10 parts to date—30 cts. each).

23209. Recent Improvements in the Utilization of Gas (G W–Began June 23—Ended July 14—3 parts—30 cts. each).

23473. Distribution of Gas. J. P. Gill (A G L J–Began July 9—Ended July 16—2 parts—15 cts. each).

HYDRAULICS.

23528. A Test of the Pohlé Air-Lift Pump at De Kalb, Ill. Ill. L. B. Merriam (E N-July 12.) 1500 w.

†23552. Canal Discharges in the Kistna Delta. Alfred Chatterton (I E-June 9.) 1600 w.

23568. A Disastrous Well (E R-July 14.) 1500 w.

23580.—$1.50. Dredging Operations.—Discussion on paper, "Reclamation of the Potomac Flats," by Peter C. Hains (T C E-May.) 5000 w.

23585—$1.50. Discussion on paper of Joseph P. Frizell, on "Storage and Pondage of Water" (T C E-May.) 800 w.

*23640. Waterworks Engineering (B-July 7.) 3800 w.

23684. Deep Well Pump Balancing. W. H. Booth (A M-July 19.) 1000 w.

23722. Water Power of the Falls of the Missouri, Great Falls, Mont. M. S. Parker (E N-July 19.) 1200 w.

23727. The Filter Question at Providence (E N-July 19.) 1500 w.

23730. The Reinforcement of Deficient Water Supply in Wells. Ill. G. D. Hiscox (Met W-July 21.) 1600 w.

23746. The Law of Water Ownership. W. A. Hancock, in Irrigation Age (F W-July 21.) 1600 w.

23831. Canals and Land Drainage and Reclamation in Florida. J. Francis Le Baron (E N-July 26.) 4700 w.

23897. Cleaning Corroded Water Mains. Ill. (E R-July 28.) 950 w.

*23917. The Devastation of Nubia. Somers Clarke (B-July 21.) 5700 w.

*23943. New Formulas for Calculating the Flow of Water in Pipes and Channels. William E. Foss (J A E S-June.) 3000 w.

†23945. The Baptism of the Great Niagara Tunnel. Emile Geyelin (P E C P-April-June.) 3500 w.

24015. The Catastrophe at Lima, Montana. J. M. Goodwin (Sc A S-Aug. 4.) 1400 w.

24016. The Draining of the Zuider Zee. Ill. (Sc A S-Aug. 4.) 2300 w.

24068. Nebraska Water Supply. A. R. McKay (F W-Aug. 4.) 1600 w.

24175. Scientific Irrigation.—Its Wonderful Progress in America and Its Benefit to Mankind. Ill. (I Age-Aug.) 1400 w.

24187. Repairs to the Maligakanda Service Reservoir, Colombo, Ceylon. Ill. Henry Ewart (E N-Aug. 9.) 5800 w.

Serials.

18801. Discharge of Sluices and Weirs under Varying Heads. G. C. Maconchy (I E-Began Dec. 9—15 parts to date—45 cts. each).

21433. Glasgow Water Works. Ill. (E-Began April 13—Ended July 13—7 parts—30 cts. each).

22670. The Danube Regulation Works. Ill. Bela von Gonda (Eng L-Began June 1—3 parts to date—30 cts. each).

23279. What a Water Supply Engineer Can Do in the Fire Department. James E. Tryon (F W-Began June 30—3 parts to date—15 cts. each).

23641. Details of Rural Water Supply (B-Began July 7—4 parts to date—30 cts. each).

23669. Centrifugal Pumps. John Richards (I S F-Began July—2 parts to date—30 cts. each).

INDUSTRIAL CHEMISTRY.

†24069. The Accuracy of the Commercial Assay for Silver. Frederic P. Dewey (J A E S-Aug.) 2200 w.

†24071. The Volumetric Determination of Phosphorus in Steel. W. A. Noyes and E. D. Frohman (J A E S-Aug.) 2200 w.

Serials.

19453. Contributions to the Chemistry of India-Rubber. P. Carter Bell (I R W-Began Jan.—5 parts to date—45 cts. each).

24076. Theory and Practice of Refrigeration I & I-Began July 27—1 part to date—30 cts).

INDUSTRIAL SOCIOLOGY.

†23538. Incidents of Labor War in America. W. T. Stead (C R-July.) 5500 w.

†23540. Employers' Liability. A. D. Provand (C R-July.) 8000 w.

23576. Lords of Misrule. Editorial (A M & I W-July 13.) 1000 w.

23579. The Law of Riot. Editorial (A S-July 14.) 900 w.

23616. The Recent Coal Strike.—The Effects, and Some Facts It Has Demonstrated. William M. Brewer (T-July 15.) 2200 w.

†23657. The Failure of the Labor Commission. Mrs. Sidney Webb (N C-July.) 10200 w.

23674. The Soft Coal Strike. Henry Bland (S V-July.) 1600 w.

†23679. Working-Class Settlements in Mulhouse and Milan. Charles Hancock (F R-July.) 5000 w.

23735. Benefits Derived from the Late Strike: Editorial (B J C-July 21.) 1200 w.

*23758. Workmen's Pension and Profit-Sharing Funds. Editorial (E-July 13.) 3500 w.

23784. New Zealand Labor Laws. John D. Connolly (R R-July 21.) 1600 w.

23809. The Industrial Belligerents. Editorial (S M-July 15.) 2000 w.

23815. Demagogues Astray. A. B. Salom (I I G-July.) 1100 w.

23835. Side-Lights on the Strike (R G-July 27.) 2200 w.

*23941. A Post Mortem Examination.—The American Railway Union. Editorial (N C B-Aug.) 1200 w.

†23959. The Lesson of the Recent Strikes I. Nelson A. Miles. II. Wade Hampton. III Harry P. Robinson. IV. Samuel Gompers (N A R-Aug.) 10800 w.

†23960. English Workmen and Their Political Friends. John E. Gorst (N A R–Aug.) 4400 w.

23967. The Wages of Labor. Editorial (M I T–July 26.) 1000 w.

*23990. After the Battle.—The Strike. Editorial (A E R J–Aug.) 5200 w.

*24087. Modes of Sharing the Proceeds of Industry.—From the Report of the Royal Commission on Labor (C G–July 27.) 6200 w.

24105. A Successful Arbitration (A A–Aug. 4.) 1200 w.

24116. Organized Labor's Rights.—From the N. Y. Law Journal (Eng–Aug. 4.) 1000 w.

24157. The Obligation of Public Service. Editorial (R R–Aug. 4.) 900 w.

LANDSCAPE ENGINEERING.

23508. The Aesthetic Value of Roads and Walks. H. A. Caparn (G & F–July 11.) 1200 w.

23700. The Use of Color in Our Parks (G & F–July 18.) 1800 w.

23701. The Gardens of the Early New England Colonists. Daniel Denison Slade (G & F–July 18.) 1300 w.

24161. The Harlem River Speedway (G & F–Aug. 8.) 1200 w.

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23501. Screw Ferry Steamer "Pleasure." Ill. (A M–July 12.) 1800 w.

23504. Vigilant vs. Britannia. Editorial (Sea–July 12.) 700 w.

23536. The Nicaragua Canal.—Its Great Value to the Country. Letter from Richard B. Hubbard, and opinions of Southern Editors (M R–July 13.) 4500 w.

23565. The First Trip by Steam from the Atlantic to the Lakes (E R–July 14.) 900 w.

†23602. The Problem of the Pole. Charles Morris (N S R–July.) 6000 w.

*23605. The Marine Interests of Italy (Tr–July 6.) 1300 w.

*23609. The Thames and Boulogne Excursion Steamer "La Marguerite." Ill. (E–July 6.) 1400 w.

23720. Constructing the "Rhumb" and Correcting the Courses of Ships. H. C. Pearsons (Sea–July 19.) 2000 w.

23721. Senator Walsh's Views on the Nicaragua Canal (M R–July 20.) 1500 w.

*23762. The Action of Screw Propellers. Ill. M. J. A. Normand (E–July 13.) 1800 w.

23782. Marine Engineers and Railway Engineers (M Rec–July 19.) 800 w.

*23883. In the Engine-Room of the "Lucania." Ill. (Eng L–July 20.) 4200 w.

*23889. On the Amplitude of Rolling on a Non-Synchronous Wave. M. E. Bertin (E–July 20.) 3300 w.

*23938. The Yachts and Yachtsmen of America. Review of book Edited by Henry A. Mott (Tr–July 20.) 1800 w.

†23994. Madras Harbor. Ill. (I E–June 30.) 700 w.

24011. Bersier's Steering Compass. Ill. (Sc A–Aug. 4.) 1600 w.

24052. Why the South Needs the Nicaragua Canal. Courtenay DeKalb, with Editorial (M R–Aug. 3.) 2600 w.

*24078. On the Importance of Economy of Fuel in Very Fast Vessels. J. A. Normand (I & I–July 27.) 1100 w.

*24080. The Nicaraguan Canal. Editorial (I & I–July 27.) 1000 w.

*24081. On the Harbor and Docks of Southampton. Ill. Mr. Dixon (Eng L–July 27.) 2500 w.

*24082. The Ventilation of Steamships and Bulk Oil Steamers. Stephen H. Terry and Fortescue Flannery (Eng L–July 27.) 1200 w.

24106. Antarctic Explorations (M Rec–Aug. 2.) 1700 w.

*24149. The Ports of China and Corea (Tr–July 27.) 2500 w.

*24151. A Year's Losses at Sea (Tr–July 27.) 1600 w.

24191. The New Ocean Steamers, St. Louis and St. Paul. Ill. (Sc A–Aug. 11.) 1200 w.

Serials.

16636. Marine Engine Design. Ill. (M W–Began Oct. 6—12 parts to date—30 cts. each).

21969. The Shark and the Sailor. A. Ewbank (I E–Began April 14—10 parts to date—45 cts. each).

22599. Forced and Induced Draught as Applied to Marine Boilers (M W–Began June 1—Ended July 6—4 parts—30 cts. each).

23761. The Vibrations of Steamships. John H. Macalpine and H. C. Flood (E–Began July 13—2 parts to date—30 cts. each).

MECHANICAL ENGINEERING.

*23484. The Modern Mechanical Drawing-Room. C. W. MacCord (E Mag–Sept.) 3000 w.

*23489. The Management of Men in Mills and Factories. W. H. Wakeman (E Mag–Sept.) 3000 w.

23500. Forging Lathe Tools. Ill. B. F. Spalding (A M–July 12.) 3000 w.

*23610. Drawing Office Methods. S. E. McNair (E–July 6.) 1500 w.

23732. An Ancient Automaton (B J C–July 21.) 1100 w.

23827. A New Recording Pressure Gauge for Extremely High Ranges of Pressures. Wm. H. Bristol, with Discussion (A M–July 26.) 1400 w.

23863. About Loose Pulleys (B J C–July 28.) 1100 w.

†23947. The First United States Pneumatic Postal System. Ill. A. Falkenau (P E C P–April–June.) 5500 w.

24023. Human Nature in the Machine Shop. Frank Richards (A M–Aug. 2.) 1300 w.

*24072. The Manchester Meeting of the Institution of Mechanical Engineers.—Account of Some of the Works Which May Be Considered as Representive of the Manchester District. Ill. (E–July 27.) 46500 w.

24127. Portland Cement (A G L J–Aug. 6.) 1500 w.

*24133. A Practical Method of Striking Arcs of Large Radius. Ill. Herbert Aughtie (P Eng–July 27.) 700 w.

*24136. Wind Motors Ancient and Modern. Sidney H. Hollands (P Eng–July 27.) 4000 w.

*24141. Remarks on the Patent System. John Richards (I S F–Aug.) 2500 w.

Serials.

17362. Arithmetic of the Screw and of Symmetrical Rings. Leicester Allen (A M–Began Nov. 16—5 parts to date—30 cts. each).

17900. Machine Ship Milling Practice. Ill. Horace L. Arnold (A M–Began Dec. 7—11 parts to date—15 cts. each).

18044. Motive Powering and Gearing. Ill. E. Tremlett Carter (El–Began Dec. 1—19 parts to date—30 cts. each).

19638. Blowing Engines and Machinery. Ill. Albrecht von Ihering (E M–Began Feb.—5 parts to date—30 cts. each).

20171. Practical Notes on Rope-Driving. Ill. M. E. (S R J–Began March—3 parts to date—45 cts. each).

23498. Notes on the Theory of Shaft Governors. Ill. Albert K. Mansfield (A M–Began July 12—Ended July 19—2 parts—15 cts. each).

23937. Some Practical Hints in Dynamo Design. Gilbert Wilkes (S R G–Began July 28—1 part to date—15 cts).

24173. The German Patent System. Gustav Bissing (E R N Y–Began Aug. 8—1 part to date—15 cts).

METALLURGY.

*23483. The Cyanide Process of Gold and Silver Extraction. Philip Argall (E Mag–Sept.) 3000 w.

23506. Permeability of Steel. Ill. Max Osterberg and Milbourne Munroe (E W–July 14.) 700 w.

23534. What Thomas A. Edison Is Doing. (From the N. Y. Sun.) (B I S–July 12.) 900 w.

23572. The Secret of Steel.—One of Its Early Discoverers (B J C–July 14.) 800 w.

23575. Modern Steel Plants. Ill. Ernst Prochaska (A M & I W–July 13.) 800 w.

23589. Concentration of Copper Ores on Lake Superior. (Abstract.) Fred. Fraley Sharpless (E M J–July 14.) 1000 w.

*23612. Separating Mixed Ores. Walter J. May (C G–July 6.) 950 w.

*23621. The Colossus of the Iron-Making World. The Carnegie Company (I C T–July 6.) 2800 w.

23687. System for Foundry Orders. F. B. Schaffer (A M–July 19.) 400 w.

23691. Dolomite as a Flux for Blast Furnace Use. E. O. Uehling (Ir Age–July 19.) 600 w.

23692. Hardening Composite Plates for Bank Vaults. Ill. (Sc A–July 21.) 900 w.

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23731. Dressing Iron Ore in Spain. (Abstract.) Frederick Kensington (A M & I W—July 20.) 1500 w.

23739. The Utilization of Waste Heat Contained in Slags from Smelting Furnaces. Ill. John Howell and E. A. Ashcroft (E M J-July 21.) 1000 w.

*23748. The Smelting and Bessemerizing of Copper Ores Ill. (C T J–July 14.) 1000 w.

*23778. Electricity in the Iron Industry (I C T–July 13.) 1200 w.

23820. Conveniences in the Foundry. H. Hansen (F D–July.) 2000 w.

23821. Some Modern Bronzes. James Larkin (F D–July.) 4300 w.

*23879. On the Determination of Phosphorus in Iron and Steel (I & I–July 20.) 800 w.

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23980. Apparatus for Breaking Pig Iron. Ill. John S. Kennedy (Ir Age–Aug. 2.) 900 w.

23981. An Economical Cupola. Ill. F. B. Whitcomb, with Discussion (Ir Age–Aug. 2.) 1400 w.

*23997. The Bessemer Steel Industry: Past and Present. Henry Bessemer (E Rev–July.) 2000 w.

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24115. Old Gold and How It Is Refined (Eng–Aug. 4.) 1400 w.

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*24160. Alloys. J. T. Hewitt (C T J–July 28.) 2200 w.

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22710. Science for Ironmongers (Iron–Began June 2—6 parts to date—30 cts. each).

22854. The Dry Assay of Ores (I & I–Began June 8—6 parts to date—30 cts. each).

23162. Iron-Making at Birmingham, Ala. Edmund C. Pechin (E M J-Began June 30—4 parts to date—15 cts. each).

23551. Malleable Iron Castings. S. Bolland (M W-Began July 6—Ended July 13—2 parts—30 cts. each).

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24075. The Manufacture of Tin Plates (I & I-Began July 27—1 part to date—30 cts).

24088. The Analysis of the Quantity of Carbon in Iron (C G-Began July 27—1 part to date —30 cts).

24170. Bulk Chlorination of Gold Ores. W. H. Gaze (A M S-Began July 7—1 part to date —30 cts).

24183. Blowing Engines.—Discussion on paper by Julian Kennedy (A M-Began Aug. 9 —1 part to date—15 cts).

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23542. The Army and Public Sentiment. Editorial (A & N J-July 14.) 1200 w.

†23678. A Lesson from the "Chicago." Nauticus (F R-July.) 5500 w.

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*23521. A Successful Slate Syndicate. Ill. (S-July.) 400 w.

*23522. The Evolution of the Slate Industry (S-July.) 900 w.

23587. The Coal Production of the World (E M J-July 14.) 1000 w.

†23601. Diamonds and Gold.—Anglo-Saxon Supremacy in South Africa. F. I. Ricarde-Seaver (N S R-July.) 4500 w.

*23613. New Theory as to Firedamp Explosions (C G-July 6.) 4300 w.

*23663. A Neglected Gold-field.—Solferino, N. S. W. (A M S-May 26.) 800 w.

*23664. Mount Huxley, Tas. (A M S-May 26.) 800 w.

*23665. A Talk About Indicators. F. D. Johnson (A M S-June 2.) 1000 w.

*23667. The Mineral Fields of Western Australia (A M S-June 9.) 1200 w.

*23668. Mallacoota—A New Victorian Goldfield (A M S-June 16.) 1500 w.

23670. Placer Mining in Alaska. Ill. (M S P-July 7.) 2800 w.

23671. Mariposa as a Mining County (M S P-July 7.) 1500 w.

23688. Notes on Fan Efficiencies. William Sangster (A M-July 19.) 1200 w.

23694. Quicksilver Mining in Tuscany (Sc A-July 21.) 750 w.

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†24166. Anthracite Coal near Perkiomen Creek. Oscar C. S. Carter (J F I–Aug.) 1300 w.

*24167. First Impressions of the Murchison. W. E. Gibson (A M S–June 23.) 1500 w.

*24168. Gold Ore Treatment at the Randt. (Abstract.) H. De Mosenthal (A M S–June 30.) 1200 w.

*24169. A Marvelous Find.—The Londonderry Mine (A M S–July 7.) 1400 w.

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23865. Notes on Some Gold-Bearing Veins of Zacatecas, Mexico. Edward Halse (E M J–Began July 28—Ended Aug. 4—2 parts—15 cts. each).

23892. Mining Ropes. (Extract.) Charles de Sinner (C G–Began July 20—Ended July 27—2 parts—30 cts. each).

24036. Metal Mining.—Methods of Obtaining and Preparing Ore Samples. Albert Williams, Jr. (C E–Began Aug.—1 part to date—30 cts).

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24152. Notes on the Philippine Islands. Frank Karuth (M J–Began July 28—1 part to date—30 cts).

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23523. Compound Locomotives for Passenger Trains. F. W. Dean (R G–July 13.) 1000 w.

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*23563. Break of Gauge Without Break of Bulk. Ill. (R W–July.) 1000 w.

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*23606. Railways and State Control (Tr–July 6.) 1600 w.

*23611. The Resistance Offered by Curves on Railroads (Eng L–July 6.) 2200 w.

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†23676. The Story of a Great Work. The St. Clair Tunnel. Ill. J. Jones Bell (P S M–Aug.) 1300 w.

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*23717. The Great Siberian Railway (R P L–June 1.) 1800 w.

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*23844. Legalized Plunder of Railroad Properties: The Remedy. Isaac L. Rice (F–Aug.) 5700 w.

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*23886. Express Locomotive Practice in England and America. Hugh Sharp (L E–Aug.) 1500 w.

*23903. Improvement of Grades and Alignment vs. Increase in Weights of Locomotives. Henry C. Thompson, with Discussion (J A E S–May.) 3800 w.

*23939. The Pooling Question in America (Tr–July 20.) 1000 w.

*23940. Early Sleeping Cars (N C B–Aug. 1000 w.

†23949. Rebuilding the Pennsylvania Railroad after the Flood of 1889. Joseph T. Richards, with Discussion (P E C P–April-June.) 4600 w.

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